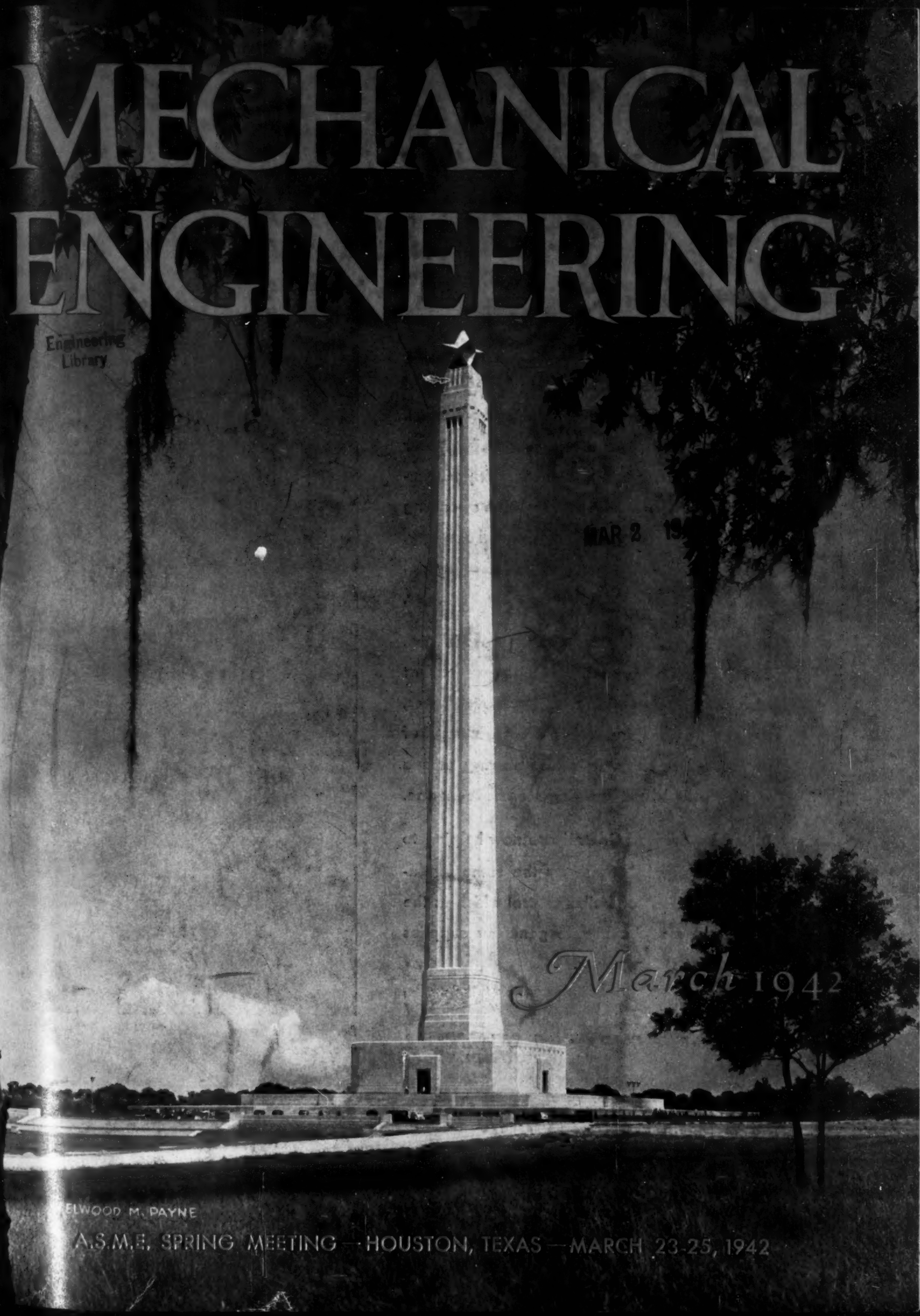
MECHANICAL ENGINEERING



March 1942

ELWOOD M. PAYNE

A.S.M.E. SPRING MEETING—HOUSTON, TEXAS—MARCH 23-25, 1942

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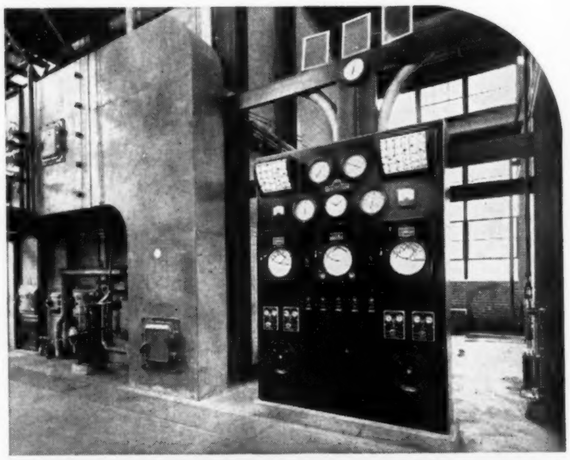

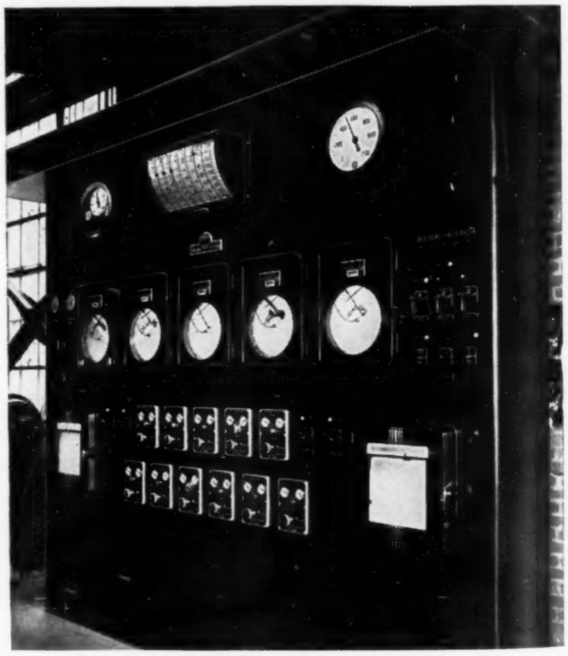

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 64 NUMBER 3

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Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Member of the Audit Bureau of Circulations.

Cushing, New York, N. Y.

Production for Victory

VOLUME 64
No. 3

MECHANICAL ENGINEERING

MARCH
1942

GEORGE A. STETSON, *Editor*

Accidents Hinder Production

THE calamitous fire on the *Normandie* is a shocking reminder of the seriousness of accidents resulting from carelessness. It would be futile to attempt an estimate of the consequences, direct and indirect, of this disheartening event. They are numerous and costly. But the case is one which brings dramatically to public notice the colossal waste that results from accidents in industry. It brings sharply to focus the urgency of precautions in industry against accidents of all kinds, major and minor, fatal and inconsequential. For although even the most thoughtless person can be shocked at seeing one of the world's largest ships lying stricken on her side, the loss is no more real because of the value and size of the vessel than is the loss by industrial accidents in, say, a week's time the nation over. At a time when shipping is urgently needed the damage to the *Normandie* is grievous indeed. But how many who rail against those whom they imagine to be responsible in the case of the *Normandie* will take the lesson to heart in their own responsibilities?

A recently issued statement, "Industrial Safety and the War Effort," by the National Safety Council, attempts to bring to everyone the seriousness of the accident problem in this country. The appeal is based on aid to our war effort as well as to the economic and humanitarian common sense of persons in all walks of life. One paragraph of this statement sums up the matter in brief and startling language. "Accidents hinder production!" it announces. "Total calculable accident costs in 1940 totaled around $3,500,000,000. The cost to industry was approximately $700,000,000, representing 17,000 deaths and 1,400,000 injuries. Had we diverted into productivity the billion and one-half man-hours lost in 1940 through work accidents, these hours would have been sufficient to construct 27 battleships, 200 destroyers, or 75,000 fighter planes."

Here, then, is a new aspect of accident prevention of vital interest to everyone—of concern to the maintenance of our way of life. It is not the loss alone that matters; it is also the criminal failure to get the most out of our production effort. In peacetime we may complacently charge these staggering costs against the hazards of life itself. In wartime we are actually jeopardizing our very existence as a free nation. The responsibility may lie most heavily upon those officially in charge of safety in industrial plants, but no man can dodge his portion of it from the time he steps out of his bath in the morning until he lies down for rest at night. He may not hold the torch that sets off a *Normandie* fire, but in lesser measure a careless act brings sudden and unpredictable consequences. You can't save a sinking ship by dropping a monkey wrench into the pump. Accidents hinder production.

Guidance of Young Engineers

A REVISION of the Engineers' Council for Professional Development "Manual for the Guidance of Young Men Interested in Engineering Education and the Engineering Profession," issued in January, will prove useful to young men contemplating an engineering career and to their parents, teachers, and advisers. The manual is addressed primarily to groups in the Founder Societies engaged in guidance activities through the medium of local advisory committees. It contains suggestions on the organization of such committees and their selection. It strongly urges the utmost co-operation with local agencies. It gives practical suggestions on what points to cover in addressing groups of boys. It contains a list of "don'ts." It covers briefly but helpfully the technique of conducting interviews.

Appended to the manual are three forms for use in the interviews. The first of these forms is to be made out by the boy himself with the view of affording information that will disclose "assets and liabilities and their relationship to occupational opportunities so that you [the boy] may be more certain of making a wise choice." The second form is to be worked out by the applicant and the counselor together and is an "appraisal of assets and liabilities." The third form affords the counselor an opportunity to record his suggestions to the applicant and his impressions and opinions of him. A bibliography of books and pamphlets on engineering guidance completes the manual.

None will deny the importance of an intelligent choice of a career. Under the present emergency, when the need for engineers is particularly urgent and widely recognized, the temptation exists of recruiting quantity at the expense of quality and aptitude. The nation, the engineering profession, and the individual are ill-served when an unwise choice is made. Engineers themselves possess the greatest competence to act as advisers to young men seeking to join their ranks. They have more at stake than any other group in seeing that able and properly qualified men are coming along to take their places. A profession that today enjoys the growing esteem of society and on which society leans so heavily in war and in peace cannot afford to admit inferior men.

Herein lies the urgency of the task laid on engineers

to assist in the guidance of the inquiring and hopeful youth. To many engineers service of this nature is pleasant and satisfying; but even so it is not to be entered into lightly or without sound preparation, as the E.C.P.D. manual warns. Organized action will be more effective in the long run in most cases than the haphazard efforts of an individual. The engineering society local section affords an organized group of recognized standing in the community with which educational institutions, parents, and boys can deal with confidence. Among its members are men competent to act as advisers. The E.C.P.D. manual provides the basis of a technique that should bring success to conscientious and intelligent effort. With such a combination, the engineering profession, the community, and the boy can be well served. Aside from the satisfactions that come to a man as a result of his own success, there is none quite so great as being able to watch a younger man who, one hopes, will someday overtop him, of whom he can say: "I helped him when he wanted to become an engineer."

Rackham Memorial

CONGRATULATIONS to the Engineering Society of Detroit are in order on the opening of its new home in the luxurious Horace H. Rackham Educational Memorial Building.

These new headquarters, which were dedicated on January 28, occupy one wing of a beautiful marble building whose central portion is given over to a large auditorium. The opposite wing serves as the headquarters of the University Extension Service and the Institute of Public and Social Administration of the University of Michigan. Thus are appropriately brought together the engineering, educational, and public administration interests of an important industrial community whose welfare and advancement are inseparably associated with those important phases of modern life.

The new building and its endowment were provided by the Horace H. Rackham and Mary A. Rackham Fund. They recall the generous gift, more than thirty years ago, by Andrew Carnegie, of the Engineering Societies Building and the Engineers' Club in New York, with this particular difference. Whereas Andrew Carnegie's gift afforded an opportunity for the uniting in a common headquarters of the national engineering societies known as the Founder Societies, the Rackham Memorial, in harmony with the present tendency for engineering to assume a position of social and economic responsibility in the world, unites in one building the local headquarters of engineering, science, and education. Moreover, in New York the Engineering Societies Building and the Engineers' Club are separate, although adjoining, buildings, and membership in one of the Founder Societies does not carry with it membership in the Engineers' Club, whereas at Detroit, clubhouse and society headquarters are identical, with privileges secured by payment of one set of dues. The arrangement prevailing at Detroit is in keeping with the spirit of the times and more easily adopted by a local society than by a group of national societies. It sets a goal toward which many groups of engineers in large industrial communities should be encouraged to work.

The location of engineering headquarters in a magnificent building in Detroit's Art Center is of great significance to the engineering profession. Here again is an indication of the present trend of recognizing engineering as a great social and economic factor on a scale which has won for it public acceptance as a cultural force. The time has passed when engineering education was looked upon as a glorified training in the mechanic arts. The scholars, the scientists, and the professional schools respect the engineers and the engineering colleges as their peers. Long years of service by high-grade men in their professional practice, in their engineering organizations, and in the civic affairs of their individual communities have earned this recognition and this acceptance. Industrialized civilization has afforded a rapidly growing number of opportunities for employment in the engineering profession and in occupations that depend upon them. The war has sharply emphasized the importance of engineering in modern life. Nations realize that their military organizations are useless without engineering skill in devising new weapons and better defenses and in supplying the staggering quantities of goods and equipment needed in modern warfare. Correspondingly, thoughtful persons realize the significant role engineering must play in postwar reconstruction and world peace. The new home of the Engineering Society of Detroit is therefore more than a reward and a recognition of the place engineers have won for themselves in society. It should be looked upon as a reminder of the faith of the nation in the engineer and it should be a source of inspiration for greater accomplishment and worthier public service.

A.S.M.E. Membership List

A CHANGE in the 1942 A.S.M.E. Membership List issued in February will, it is believed, be welcomed by a majority of users. No longer are the principal data to be found in the geographical list. Addresses are now to be found in the alphabetical list and the new arrangement will save time and annoyance.

With the 1942 Membership List has been included as usual the complete list of officers, personnel of committees, professional divisions, local sections, and student branches. The A.S.M.E. Constitution, By-Laws, and Rules have been added to the 1942 volume, and the Professional Consulting Service Index, introduced in 1940, appears for the second time. Thus the 1942 Membership List becomes a source of information about the Society and its members.

An attempt has also been made to afford easy access to information about the A.S.M.E. contained in the new edition. A page has been added just inside the front cover that not only directs the user to the indexes, but also to sources of information about membership, local sections, publications, employment service, and the Engineering Societies Library.

VIBRATION *and* RUBBER SPRINGS

Design Details to Be Considered in the Application of Rubber Mountings to Machinery

By WALTER C. KEYS

MECHANICAL PRODUCT ENGINEER, UNITED STATES RUBBER COMPANY, NEW YORK, N. Y.

THE phenomenal "smoothness" of America's most personal piece of machinery, the modern automobile, has created an almost universal demand that machinery of all kinds shall have the following characteristics:

1 Attractiveness of appearance.
2 Reasonable quietness.
3 Reasonable freedom from vibration.

This is evident in late models of machine tools, locomotives, refrigerators, vacuum cleaners, and the like.

Because rubber is a poor conductor of noise and because it can be fabricated into economical, simple, and effective springs, or mountings, it is now very widely used as one of the structural materials that are essential in many types of modern mechanism.

It is the purpose of this paper to deal with rectilinear vibration, and (*a*) to illustrate a few practical applications of rubber, (*b*) to present typical quantitative results, (*c*) to include data as to resonance frequencies of vibratory movement of mountings made of typical rubber compounds bearing typical safe loads, and subjected to a range of vibrations, such as are encountered in many actual applications.

The theory of vibratory behavior is well explained in several excellent books on the subject. In a text[1] by J. P. Den Hartog appears the following, referring to the effectiveness of springs (or mountings) used to reduce transference of vibration

$$\text{Transmissibility} = \frac{\text{Spring force}}{\text{Impressed force}} = \frac{\text{Transmitted force}}{\text{Impressed force}}$$

It is further designated, where damping is negligible, as

$$\frac{1}{1 - \left(\dfrac{\text{Forced frequency}}{\text{Natural frequency}}\right)^2}$$

For convenience, the author of this paper designates as the "frequency ratio"

$$\frac{\text{Forced frequency}}{\text{Natural frequency}}$$

The relationship between natural frequency and static deflection of a supporting spring which deflects according to Hooke's law is

$$\text{Natural frequency (per minute)} = \frac{188}{\sqrt{\text{Static deflection (in.)}}}$$

The foregoing relations apply to an undamped single-degree system and are substantially correct for rubber springs.

The chart, Fig. 1, gives in terms of deflections the natural frequencies, also the forced frequencies for transmissibilities of 81 per cent (frequency ratio 2.5 : 1) and 93 per cent (frequency ratio 4 : 1). Curves for other transmissibilities can be drawn in using the guides at the top of the chart. This chart is useful in establishing the static deflection of mountings required to absorb a wide range of forced frequencies.

Transmissibility, as defined in the textbooks, provides the ideal, theoretical solution to rectilinear-vibration problems. However, in actual cases it is seldom possible to change only the stiffness of mountings; hence the actual reduction of vibratory amplitude may be either slightly greater or less than the calculated transmissibility. This is evident in the actual results given herein. For convenience, the term "amplitude residue" is herein used to designate

$$\frac{\text{Amplitude of movement resiliently mounted}}{\text{Amplitude of movement rigidly mounted}}$$

referring to the vibratory movement of that portion of any mechanism or structure to be protected by the mountings. This "amplitude residue" is equal to the transmissibility under ideal testing conditions which, unfortunately, are rarely encountered. Hence, transmissibility is used as the goal, and "amplitude residue" as a measure of accomplishment.

TECHNIQUE

In general the engineer requires the following information in attacking problems involving isolation of vibration by means of resilient supports:

1 Total weight to be supported.
2 Location of center of gravity.
3 Lowest frequency of vibration to be insulated.
4 Direction and plane of the vibration.
5 Reactions (if any) to be resisted by the mountings (such as torque, forces due to driving belts, chains, gears, etc.).
6 Number, location, and size of attaching bolts.
7 Type, location, and size of all connections from resiliently supported unit to foundation members (such as conduits, piping, driving shafts, and the like).
8 The "rate per inch" or spring constant of such connections.
9 Type of supporting foundation.
10 Clearances between parts of supported unit and adjacent members not supported by the mountings.
11 Proximity of oil, water, temperature, exposure to sunlight or ozone.
12 As complete information as possible regarding the conditions of use.

In general, a wall of rubber is more flexible in shear than in compression. Therefore, it is customary to install the shear planes of mountings parallel to the plane of vibratory movement of the supported unit unless prevented by special conditions, such as the necessity of withstanding heavy tension of belt, and the like.

[1] "Mechanical Vibrations," by J. P. Den Hartog, second edition, McGraw-Hill Book Company, Inc., New York, N. Y., 1940.

Contributed by the Rubber and Plastics Subdivision of the Process Industries Division and presented at the Annual Meeting, New York, N. Y., December 1–5, 1941, of The American Society of Mechanical Engineers.

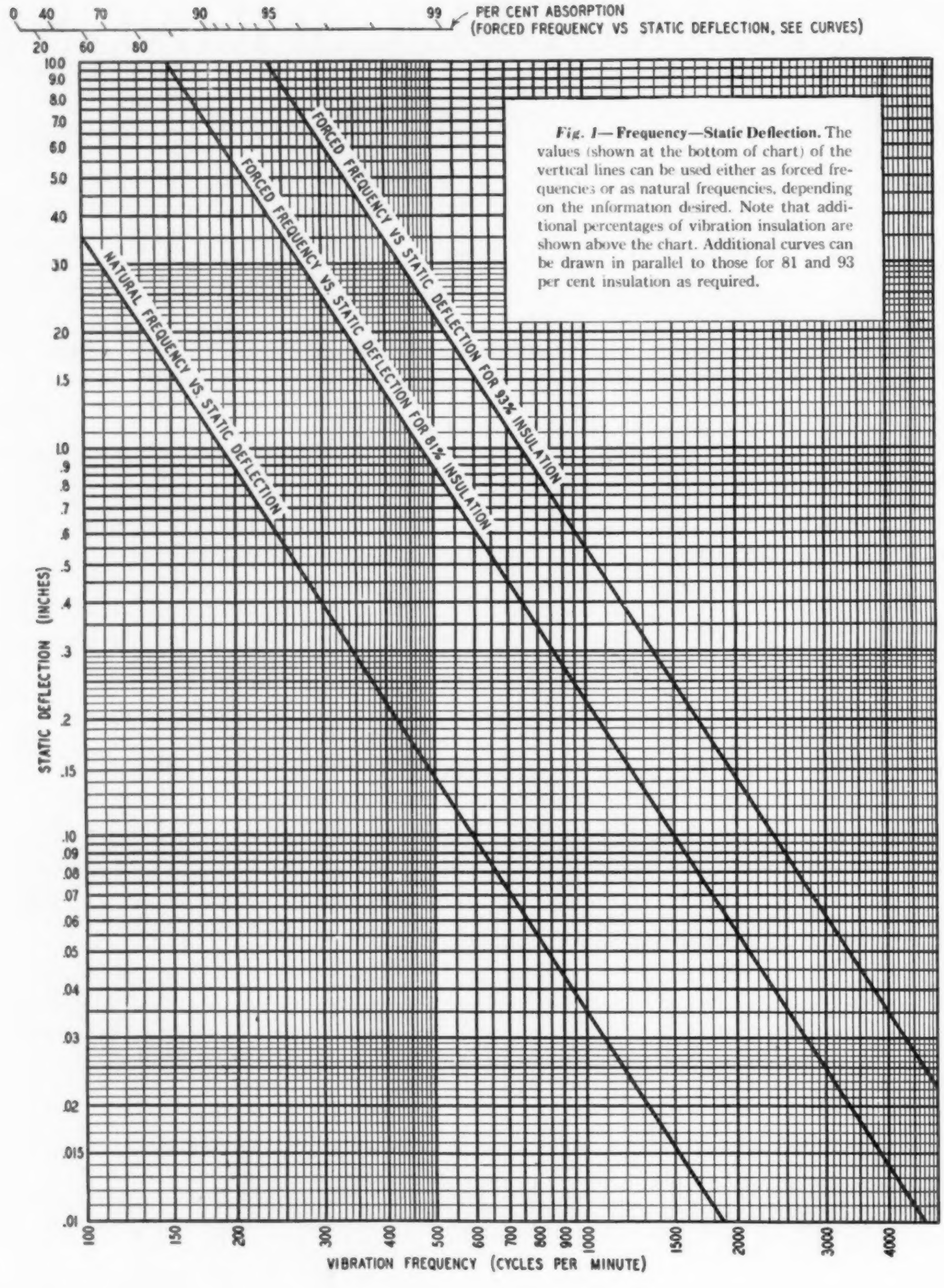

Fig. 1—**Frequency—Static Deflection.** The values (shown at the bottom of chart) of the vertical lines can be used either as forced frequencies or as natural frequencies, depending on the information desired. Note that additional percentages of vibration insulation are shown above the chart. Additional curves can be drawn in parallel to those for 81 and 93 per cent insulation as required.

The average simple problem is readily solved by mountings which provide the deflection indicated on the chart, Fig. 1. In almost all industrial work a frequency ratio of $2^1/_2$ to 1 produces satisfactory results. In exceptional cases where the supporting floor is very flexible it has been necessary to use a frequency ratio of 8 : 1. The author has never been obliged to exceed this value.

It is well to indicate at this point that these frequency ratios may appear small to the acoustical engineer interested in noise reduction; but it should be remembered that the usual noise frequencies are very much higher than the usual fundamental mechanical frequencies which are being insulated; hence the frequency ratios for the noises are very much higher than those mentioned, and the insulation of noise transmission is greater than would appear at first glance.

Where the vibration is in a horizontal plane, it can usually be absorbed most economically by installing the machine on rubber-to-metal sandwiches carrying the gravity load in compression and absorbing the vibratory movement by deflecting in shear. The required horizontal stiffness can be determined by assuming gravity to act horizontally and obtaining from the chart the required static deflection. The total load, in pounds, divided by this static deflection, in inches, gives the horizontal "rate per inch," or spring constant of all the supporting mountings. The mountings must be designed (or selected) so as to have adequate carrying capacity in compression while, at the same time, they must have the proper stiffness in shear. Furthermore, the stiffness in compression must be such as to avoid resonance vertically with the horizontal vibration. Note that the actual dynamic horizontal deflections of the mountings may be and usually are very much less than the assumed static horizontal deflection obtained from the chart.

Since the natural frequency of a supported mechanism is less than the forced frequency, the mechanism may pass through resonance when changing to or from its operating speed. This will produce a relatively large deflection which usually subsides very quickly. In extreme cases, such large deflections are limited in extent by rubber bumpers which, however, must not be in contact when the machine is operating normally.

The stress on the rubber-to-metal bond is easily determined when the shear deflection is known:

$$\text{Bond stress (psi)} = \frac{\text{Shear deflection}}{\text{Rubber thickness}} \times \text{Shear modulus}$$

Static bond stress is usually kept at 25 to 50 psi. In special cases, however, it may exceed this range. It is generally considered good practice to stress under compression all rubber elements which are to be stressed in shear. An unusual installation is that shown in Fig. 2, in which the arrangement of shear mountings produces compressive stress on the rubber which, however, absorbs the vibration by deflecting in shear.

Fig. 3 illustrates the disposition of mountings and the use of links to assure stability in cases where the resiliently supported unit is subjected to appreciable horizontal forces in addition to gravity.

Fig. 4 illustrates a method of steadying a board drop hammer

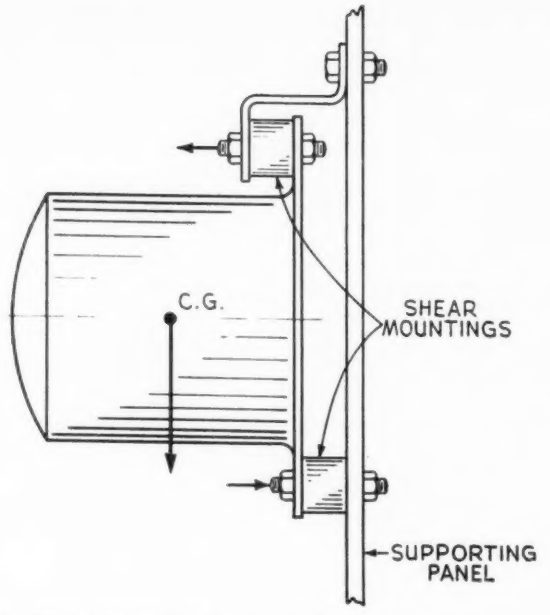

FIG. 2 HOW COMPRESSION IS APPLIED TO VERTICAL MOUNTINGS WHICH ABSORB VIBRATION IN SHEAR

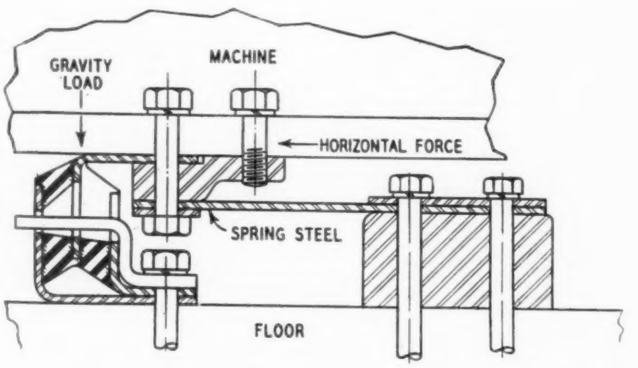

FIG. 6 METHOD OF PREVENTING HORIZONTAL MOTION WHILE ABSORBING VIBRATION IN VERTICAL PLANE

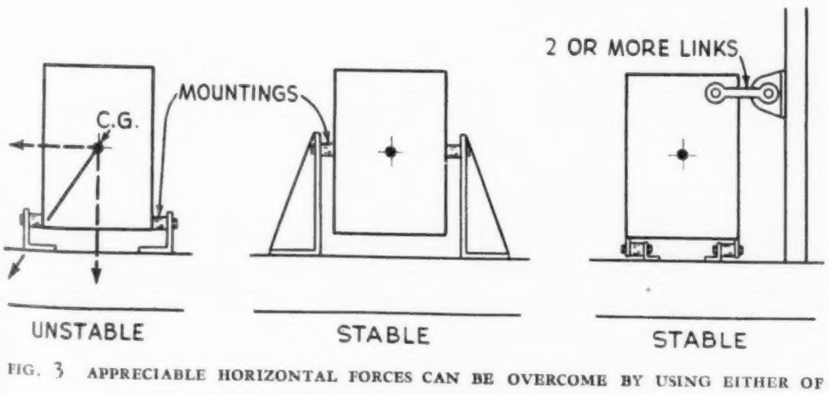

FIG. 3 APPRECIABLE HORIZONTAL FORCES CAN BE OVERCOME BY USING EITHER OF TWO RIGHT-HAND SUPPORTING METHODS

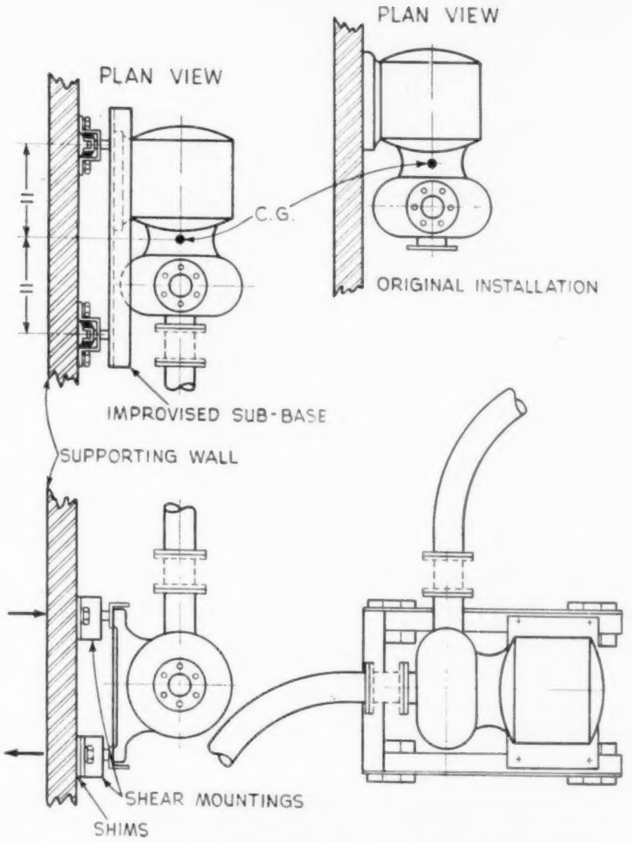

FIG. 5 SUBBASE PERMITS IDENTICAL MOUNTINGS, EQUALLY LOADED, AT ALL SUPPORT POINTS IN A CASE WHERE MOUNTINGS ARE UNEQUALLY LOADED

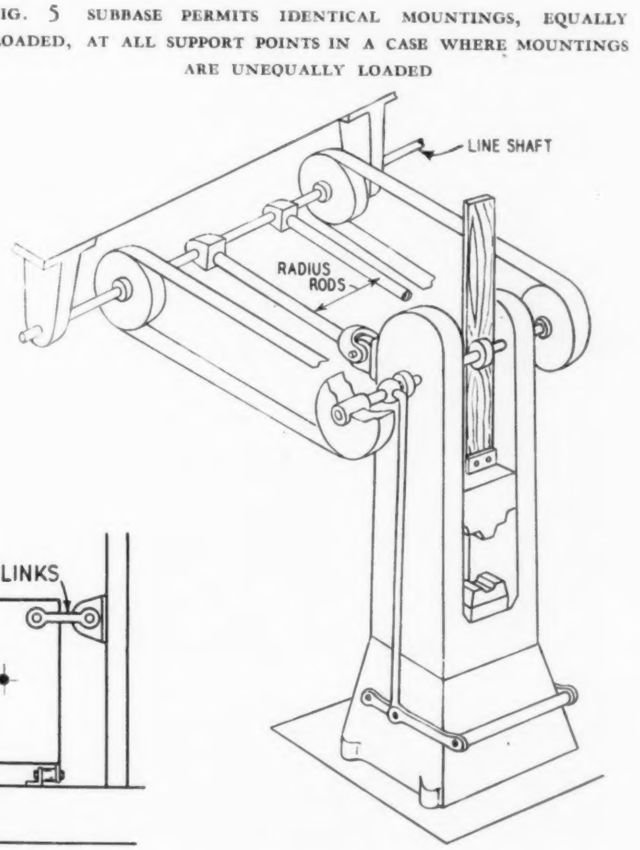

FIG. 4 METHOD OF OVERCOMING VIBRATION OF A BOARD DROP HAMMER WITH RADIUS RODS TO SECURE STEADINESS

driven from a line shaft. The radius rods overcome an objectionable teetering of the machine.

Frequently, the engineer is required to prescribe mountings for a machine assembly the location of whose center of gravity is unknown and cannot be obtained from the manufacturer. In such cases the machine can sometimes be placed on skids resting on a pipe. The machine can be rolled on the pipe until it balances. The center of gravity will be above the line of contact of the pipe with the skid; a second trial with the pipe at 90 degrees to its first position will establish a second line above which the center of gravity is also known to be. If necessary to know the height of the center of gravity, tip the machine until it balances over an edge of its base and the center of gravity will then be vertically above that edge.

In cases where mountings are unequally loaded the stiffness of each mounting should be chosen so that it will deflect the required amount under the load imposed upon it. In cases, such as that shown in Fig. 5, a subbase may be secured to the mechanism in such a manner as to permit the use of identical mountings, equally loaded, at all supporting locations.

Fig. 6 shows an arrangement in which vertical insulation was required, but horizontal movement could not be tolerated and was prevented by a single-plate steel spring connecting the supporting floor with the supported machine.

The stiffness of all connections from supported unit to foundation members must be taken into account when mountings are prescribed. A mechanism may be installed on mountings which entirely support it, and thereafter it may be connected to some more or less flexible conduit, pipe, etc., which is also joined to foundation members. The apparent static deflections must be obtained by adding together the rates per inch (or spring constants) of all mountings and connections and dividing this sum by the total load to be carried. From this apparent static deflection the natural frequency and frequency ratio can be determined. Failure to follow this procedure may result in resonance and complete dissatisfaction.

Sometimes the frequency of disturbance can be easily established without instruments, as follows:

1 Secure a sharp pencil to the vibrating machine.

2 Move a sheet of paper (contacting the pencil point) for 6 sec, approximately at right angles to the direction of movement of the pencil which will draw a wavy line on the paper. Ten times the number of wave tops is the frequency per minute. The approximate amplitude of vibratory movement can also be determined in this manner.

The strobotac or some modification thereof may be of great value in studying the behavior of machinery. Moreover, it is frequently possible to operate one part only of a complicated mechanism so as to study the effect of that part on the behavior of the whole.

Mountings should be kept free of oil and should not be subjected to temperatures above 150 F. Sometimes both results can be accomplished by extending arms or brackets outwardly from a machine to the mountings which can be favorably located. In some types of applications (such as underneath railroad passenger cars), it may be impossible to observe the dynamic behavior of resiliently mounted units. By the use of

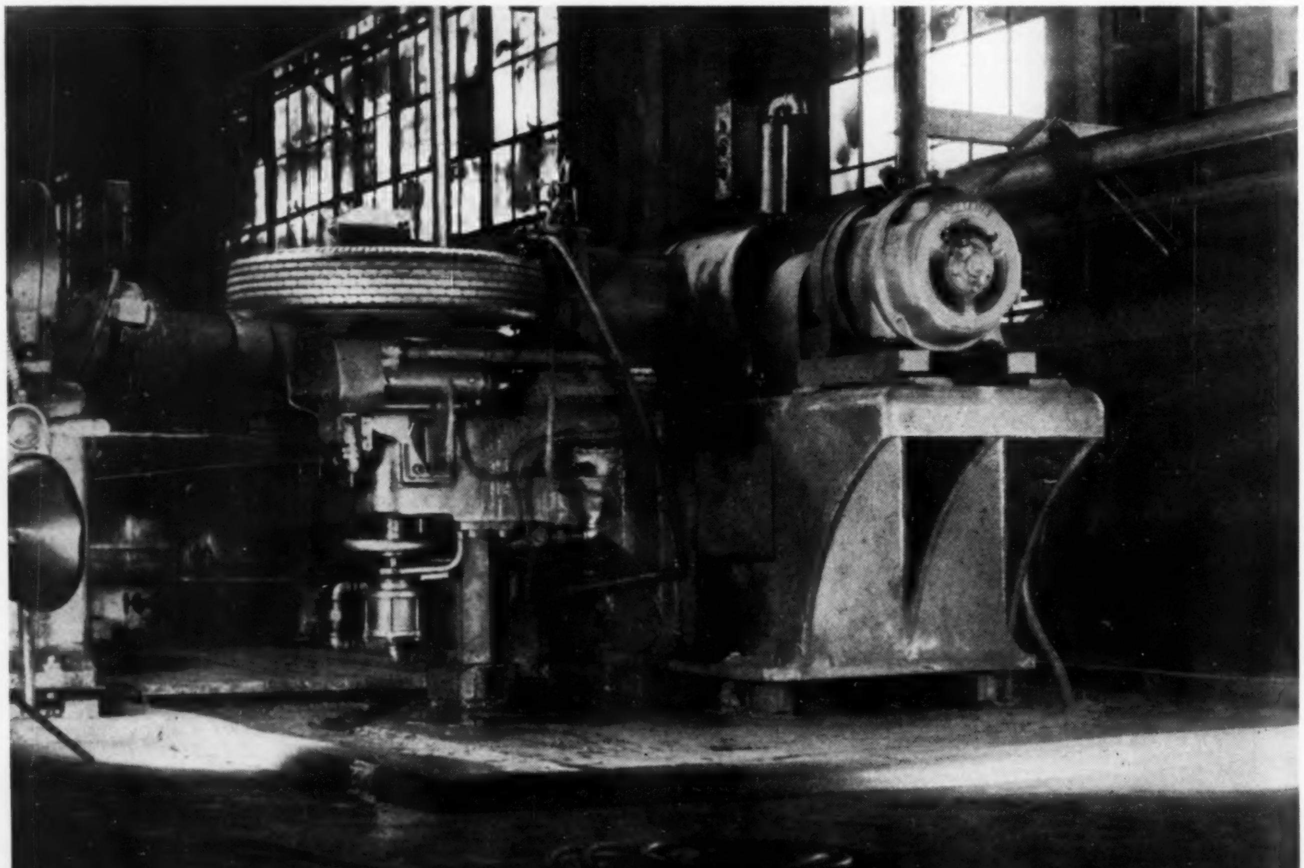

FIG. 7 RUBBER SPRINGS REDUCE VIBRATION

(When working at high speed this tire-tread perforating machine transmitted a sufficient amount of vibration to building structure to present a safety problem. Placing the heavy machine on rubber mountings solved the problem satisfactorily.)

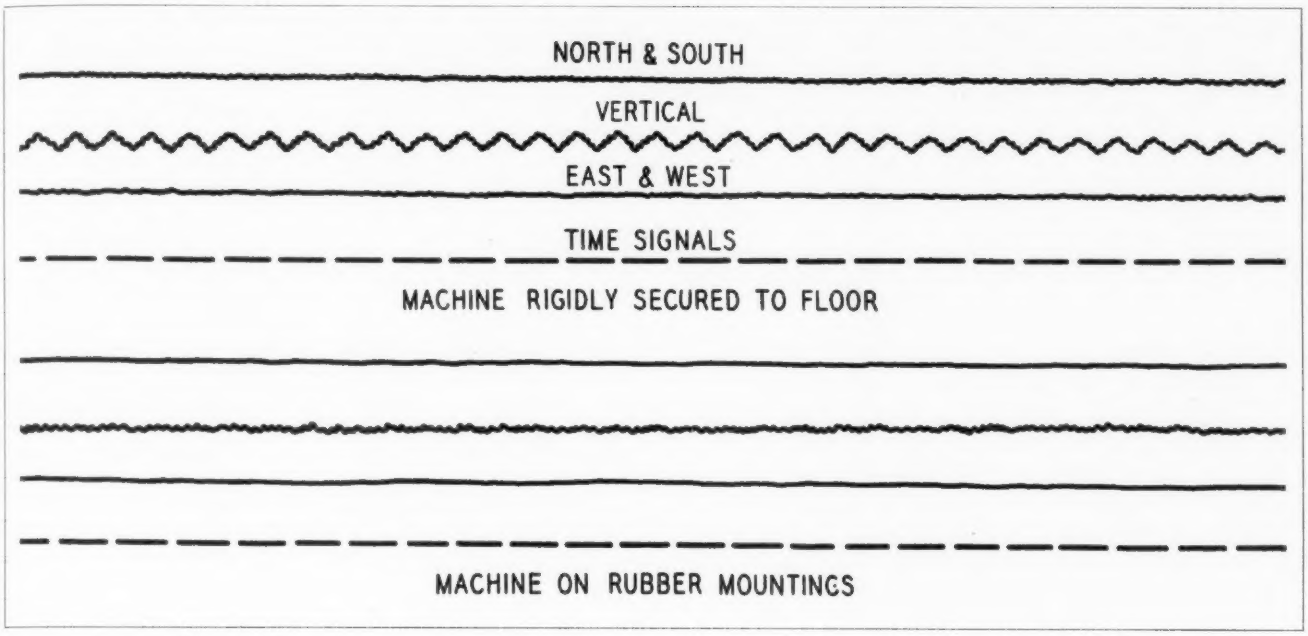

FIG. 8 "BEFORE-AND-AFTER" VIBRATION RECORDS OF SUPPORTING FLOOR, TAKEN DURING OPERATION OF MACHINE

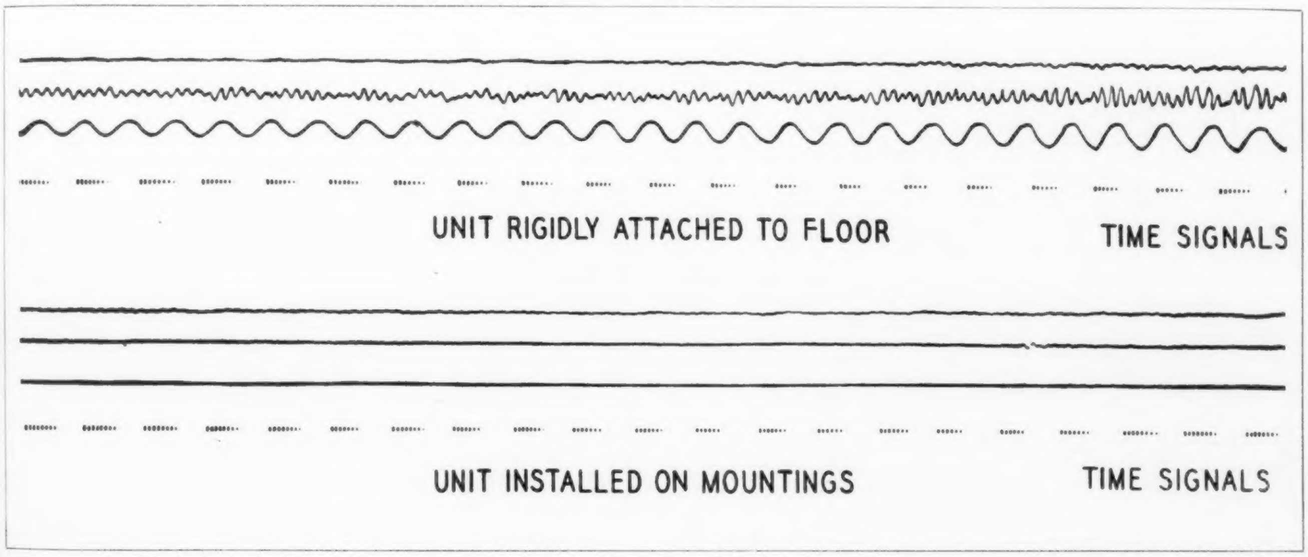

FIG. 9 UPPER CHART IS RECORD OF MACHINE-TRANSMITTED VIBRATIONS WHICH DISTURBED LABORATORY APPARATUS. RUBBER MOUNTINGS EFFECTED RESULT SHOWN BELOW

pry bars, however, it may be possible to force such a unit into the position of its maximum deflection so as to study the stress on the mountings, also the clearances between parts of the mechanism, foundation, etc.

QUANTITATIVE RESULTS—EXAMPLES

Fig. 7 illustrates a machine used for perforating treads of tires. The reciprocating action of the machine caused vibration which was dangerous to the building.

Fig. 8 shows records of the vibration of the supporting floor, obtained when only one machine was operating (*a*) while rigidly secured to floor, and (*b*) while supported by rubber mountings. In this case, the average amplitudes of floor movement obtained by calibrating the accelerometer records give: Amplitude residue

$$= \frac{0.00042 \text{ in. (Amplitude resiliently mounted)}}{0.00282 \text{ in. (Amplitude rigidly mounted)}} = 14.9 \text{ per cent}$$

The calculated transmissibility was 18 per cent. This accomplished all that was desired. It may be remarked that more effective insulation could be prescribed but the cost would be greater.

Fig. 9 is a reproduction of records of vibration obtained in a building carrying sensitive laboratory apparatus but being disturbed by a reciprocating machine. An insulated foundation for the apparatus was provided. Quantitative records were made, with the following result as to the average vertical amplitudes: Amplitude residue

$$= \frac{\text{Amplitude of insulated unit}}{\text{Amplitude of supporting floor}} = \frac{0.000012}{0.00608} = 0.19 \text{ per cent}$$

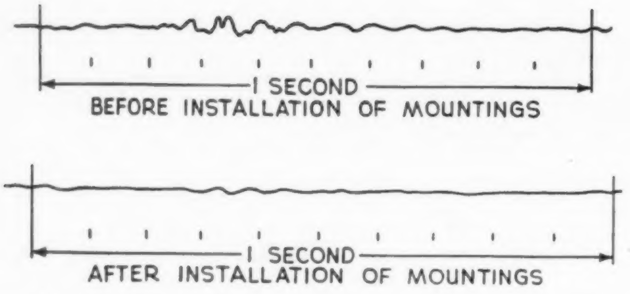

FIG. 10 RECORDS OF "EARTHQUAKES" CAUSED BY FORGING HAMMER

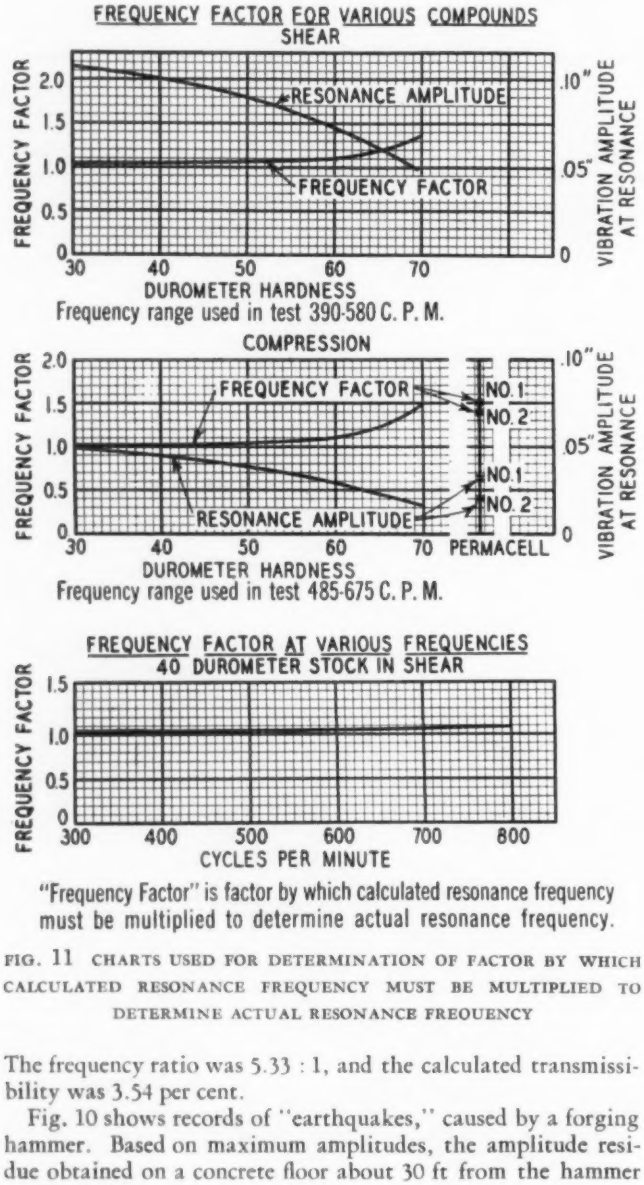

FIG. 11 CHARTS USED FOR DETERMINATION OF FACTOR BY WHICH CALCULATED RESONANCE FREQUENCY MUST BE MULTIPLIED TO DETERMINE ACTUAL RESONANCE FREQUENCY

The frequency ratio was 5.33 : 1, and the calculated transmissibility was 3.54 per cent.

Fig. 10 shows records of "earthquakes," caused by a forging hammer. Based on maximum amplitudes, the amplitude residue obtained on a concrete floor about 30 ft from the hammer was as follows:

$$\frac{\text{Amplitude after insulating}}{\text{Amplitude before insulating}} = \frac{0.00076}{0.00331} = 23 \text{ per cent}$$

The calculated transmissibility was 20.4 per cent.

Usually it is unnecessary to obtain quantitative data pertaining to mounting installations, because the extent to which the annoyance is eliminated is evidenced unmistakably by the personnel originating the project.

DYNAMIC PERFORMANCE OF MOUNTINGS

The following data are given to enable the engineer to approximate the performance he may expect from rubber springs to be used for insulation of vibration encountered in the average case:

Standard mountings, 1.25 in. diam × 1.09 in. effective rubber length, made of five standard mounting compounds, were used in laboratory tests to determine the relationship between actual and calculated resonance frequencies, obtained by using rubber stressed both in shear and compression, in accordance with typical practice. In addition to the solid-rubber mountings, a few tests were made on structural cellular rubber known as "Permacell."

Essentially, the experiments consisted of supporting, with the mountings under test, a weighted platform which was caused to vibrate by means of a double-eccentric weight arrangement which produced vertical vibratory forces without comparable horizontals. Amplitudes of vibration were measured by means of a dial gage in contact with the platform; eccentric speeds were established by means of a strobotac; vibration velocities were obtained through the General Electric velocity meter. The eccentrics were driven from a variable-speed motor. Testing speeds varied from about 250 to 1750 cycles per min.

During the tests, the number of mountings comprising a given rubber compound was chosen to give approximately the same static deflection with approximately the same weight as samples of other compounds stressed in the same manner. Thus, for the hardest compound, only four samples were used, whereas, sixteen samples of the softest compound were used to approximate the same static deflection.

Auxiliary tests were made employing the most generally used mounting compound (No. 5133, 40 durometer) stressed both in compression and shear. In these tests the frequency of resonance was caused to vary over a fairly wide range to permit determination of the frequency factor (or the factor by which the calculated resonance frequency must be multiplied to determine the actual resonance frequency).

In the charts, Fig. 11, the results of the foregoing tests are given. Compounds of 30, 40, and 50 durometer are used most extensively for rubber mountings. In the lower frequencies (up to about 600 cycles per min) calculated static deflection may be used without correction (except above 60 durometer).

The amplitude at resonance is much smaller for the harder compounds than for the softer ones. However, the harder compounds are almost never used, since their cost for a given deflection is higher, and they are more susceptible to drift or permanent set. Permacell can be deflected (statically) only about 10 per cent of its thickness, but it can be operated closer to resonance than solid rubber of 30 and 40 durometer.

LIFE OF RUBBER MOUNTINGS

As with any other commodity, the life of rubber mountings depends entirely upon the abuse to which they may be subjected. When used under favorable conditions, mountings may be expected to function satisfactorily for at least six years. We have records of much longer life. It is of course obvious that the longer the life requirement, the less must be the stress and abuse to which the mountings are subjected.

ACKNOWLEDGMENT

The author is indebted to Drs. S. M. Cadwell and S. A. Black, also to C. M. Sloman, of the United States Rubber Company, for their efforts and co-operation in obtaining essential data.

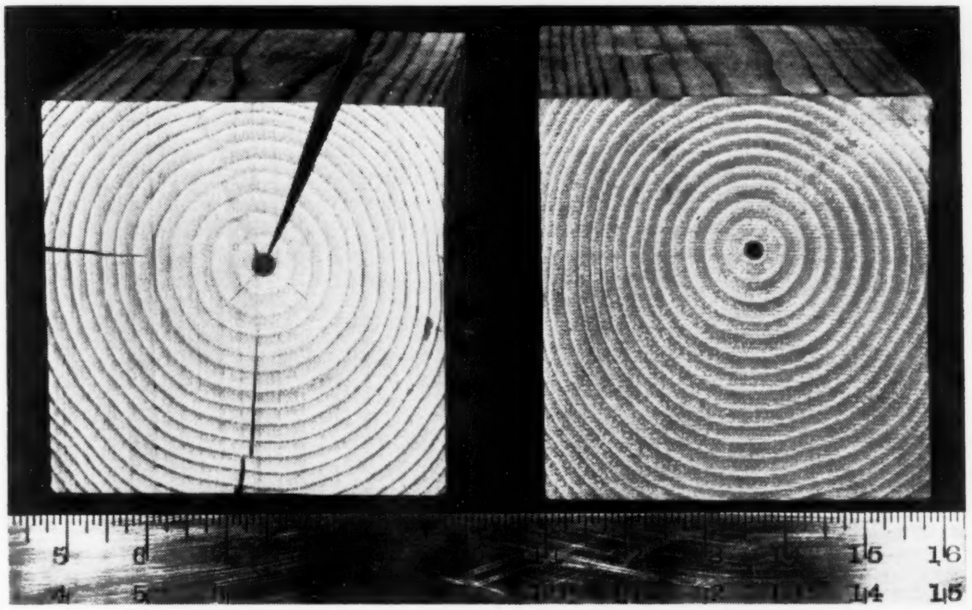

FIG. 1 DOUGLAS FIR SECTION FROM MATCHED BOXED-HEART TIMBERS, ONE UNTREATED AND THE OTHER TREATED WITH UREA (Both specimens were dried under the same air-drying conditions; urea was applied dry to green wood at the rate of 40 lb per 1000 fbm and wood solid-piled for 1 week prior to strip-piling.)

UREA TREATMENT *of* LUMBER

By J. F. T. BERLINER

E. DU PONT DE NEMOURS & COMPANY, INC., WILMINGTON, DEL.

GREEN lumber dries by the movement of water toward the drier outside fibers where the water evaporates. This movement continues until the entire piece reaches a moisture content in balance with that of the surrounding air. The outer zone of the drying wood, because it has less moisture, has a lower vapor pressure than the wetter inner zone. This difference in vapor pressure results in the movement of moisture toward the outside. The rate of moisture loss is normally controlled by the temperature and moisture content—or the relative humidity—of the surrounding air. The lower the relative humidity of the air, the faster the evaporation of surface moisture. However, if the relative humidity is lowered too rapidly, the wood will check severely. The proper control of the relative humidity at the surface of drying lumber is essential to prevent checking.

Moisture is present in freshly cut green wood as free and as hygroscopic water. The water held in the cell cavities and other spaces is termed free water, and that in the fiber or cell walls is the hygroscopic water. When wood dries the free water evaporates first. After it has all left and only the water in the fiber walls remains the fiber-saturation point is reached. The loss of free water causes no change in the dimensions of the wood. The water content at the fiber-saturation point, which is different for each species of wood, varies from 20 to 30 per cent of the dry weight of the wood. When the fibers lose hygroscopic water their thickness is decreased and shrinkage results.

WHY WOOD CHECKS

Lumber checks and splits on drying because of uneven shrinkage resulting from the development of a moisture gradient, and unequal shrinkage of wood in different directions, as its moisture content decreases. Wood begins to shrink as it dries below its fiber-saturation point. It will continue to shrink as long as it loses moisture. When green lumber dries rapidly, the outer zone may dry below the fiber-saturation point, and begin to shrink, while the interior is still quite green. The surface fibers become stretched, as their normal tendency to shrink is restrained by the still swollen interior. The tension stresses which ensue may exceed the strength of the fiber bond, and splitting and surface checking result. Since in seasoning green wood the surface dries more rapidly than the interior and reaches the fiber-saturation point first, shrinkage starts while the average moisture content of the wood is considerably above the fiber-saturation point. Therefore, checking is most likely to occur in the initial stages of drying.

The shrinkage of all woods on drying is much greater tangentially to the rings of the tree than radially or across the rings. Longitudinal shrinkage, or shrinkage along the length of the board, is exceedingly small. This unequal shrinkage tends to cause surface checks and splits, particularly along the wide grain of flat-sawed lumber. The effect of this unequal shrinkage is most pronounced in drying cross sections of trees, such as are used for exhibit purposes and in boxed-heart lumber where the pith of the tree is enclosed, because stresses occur on all sides. Such pieces check more readily and more severely than side-cut or quarter-cut lumber.

HOW CHEMICALS REDUCE CHECKING

If the surface of lumber is kept from shrinking or developing tension stresses during drying, checking is prevented. Shrinkage can be prevented either by keeping the moisture content of the wood above its fiber-saturation point, or by introducing some material into the wood structure that will prevent shrinkage on drying. A number of substances will perform one or, in some instances, both of these functions. Chemical seasoning

Contributed by the Wood Industries Division and presented at the Fall Meeting, Louisville, Ky., October 12-15, 1941, of The American Society of Mechanical Engineers.

is the process of applying a water-soluble hygroscopic antishrink chemical to the surface of green lumber to allow the lumber to be air- or kiln-dried with the minimum of seasoning degrade. Seasoning degrades include splitting, checking, honeycombing (hollow horning), warping, and internal collapse. The chemical penetrates the surface zone of the green lumber by diffusion, and maintains the outer zone in a relatively moist and swollen condition as the inside of the piece dries. As the drying progresses beyond the fiber-saturation point, the chemical resists further shrinkage by its physical presence within the wood fiber. No chemical reaction between the wood and the chemical used is involved.

Introduction of a chemical into the water in the surface zone of green lumber results in a lowering of the vapor pressure of this zone, compared with that in the adjacent untreated zone. This produces a vapor pressure gradient causing the moisture to move from the inside of the wood to the surface, just as in the case of ordinary drying, except that the surface zone remains in a moist, swollen state. The ordinary drying process depends upon a reduction in the surface moisture to produce a lowering of the vapor pressure, whereas, in chemical seasoning, the vapor pressure at the surface is reduced by the solution of the chemical in the moisture of the wood. Thus, in chemical seasoning as in ordinary seasoning, drying is induced by a vapor pressure gradient between the surface and the inner zone of the lumber, but without excessive drying of the surface.

Lumber immersed in a solution of a chemical or containing the chemical dissolved in its surface moisture will dry just as rapidly as it would in air at the same temperature and having a relative humidity in equilibrium with the vapor pressure of the solution. It is possible to dry lumber to well below its fiber-saturation point by soaking it in solutions of certain chemicals at selected temperatures and concentrations.

Within the treated zone, the chemical is present in the pore cavities of the wood and particularly in the fiber structure of cavity walls. When the treated wood is dried the chemical is deposited in the wood structure and by its bulk opposes the tendency of the fibers to shrink. In general, the more soluble the chemical, the more effective the antishrink effect, in that higher concentrations can be introduced.

CHOICE OF A CHEMICAL SEASONING AGENT

Many factors enter into the choice of a chemical for use as a seasoning agent. A number of materials will reduce the surface checking of certain species of wood, but most of these have undesirable features which preclude them from further consideration. The chemical should be highly soluble in water, noncorrosive, inexpensive, readily available, stable, and nontoxic. It should be sufficiently hygroscopic to retain moisture during the drying process, but not so hygroscopic as to cause the dry wood to become damp under conditions of high humidity. Selection is quickly limited to about two dozen products because of cost, while corrosion hazards and toxicity rule out all but a very few. Of all substances considered for chemical seasoning, urea has proved most satisfactory in both laboratory investigations and commercial-scale mill tests. Urea has been found to be superior to other materials tested or considered because it combines the following advantages:

1 Effectively reduces seasoning degrades, particularly checking and splitting, in both air and kiln drying.

2 Is not corrosive to metals used with wood.

3 Does not dull saws, planer knives, or other woodworking tools.

4 Does not cause dampening of treated lumber after the drying period, even under conditions of high humidity.

5 Does not promote insect or fungus attack, and inhibits certain rot fungi.

6 Does not discolor wood kiln-dried green from the saw at moderate temperatures, or lumber appropriately treated and air-dried.[1]

7 Makes wood more flame-retardant.

8 Is nonpoisonous and harmless to the skin.

9 Is stable and can be stored without deterioration.

10 Does not affect the gluing characteristics of the wood.

11 Has shown no effect on paint, varnish, or lacquer finishes on extended outdoor-exposure tests.

12 Is low in cost, and inexpensive to apply.

13 Is compatible with fungicides used on green lumber and can be used in conjunction with them.

14 Does not conduct electricity.

PROPERTIES OF UREA

Crystal urea, also known as carbamide, is a white, crystalline solid resembling granulated table sugar in appearance. Its chemical formula is $(NH_2)_2CO$. Urea has a high negative heat of solution in water, —104 Btu per pound, resulting in considerable cooling as it dissolves. This should be taken into consideration when preparing urea solutions. In dissolving urea, it is advisable to employ hot water or to apply heat by means of a steam coil. Urea is very soluble in water and its solution is accompanied by a marked increase in volume as illustrated in Table 1.

TABLE 1 SOLUBILITY OF UREA IN WATER

Temperature, F	Water to dissolve 100 lb of urea, Lb	Water to dissolve 100 lb of urea, Gal	Resulting volume, gal	Specific gravity, 60°/60 F
50	119	14.25	23	1.135
60	106	12.75	21.5	1.141
70	93	11.25	20	1.147
80	83	10.0	19	1.153
90	72	8.75	18	1.158
100	65	7.75	17	1.163
110	57	6.75	16	1.168
120	51	6	15.5	1.172

Urea is manufactured through the controlled reaction of liquid ammonia and liquid carbon dioxide at high pressures. While urea was the first organic compound to be synthesized (1828), and the subject of what was probably the first patent ever granted (1561), it was not manufactured on a large commercial scale in the United States until 1935. Its principal industrial uses are as an ingredient of fertilizers and synthetic resins and in the manufacture of textiles, paper, and adhesives.

APPLICATION OF UREA TO WOOD

To be effective, urea must penetrate and be present in the outer shell of the green lumber. The higher the green moisture content of the wood, the more readily will this penetration take place. It is therefore essential to apply the urea to the green wood as soon as possible after sawing. Urea penetrates into wood by diffusion into the water of the wood. If the moisture content of the wood is too low to provide a continuous film of water, the action is greatly impeded. The amount, depth, and rate of penetration of the urea into the wood are directly associated with the moisture content of the wood.

The quantity of urea required varies with the species, dimensions, and cut of lumber. For hardwoods less than 2 in. thick, and softwoods not thicker than 6 in., 40 to 60 lb of urea per

[1] Some woods darken slightly at high kiln temperatures. Occasionally a slight discoloration develops in treated white oak if exposed to rain during air seasoning, and in the sapwood of Douglas fir when allowed to remain solid-piled too long. Where these unfavorable conditions cannot be avoided, methods for correcting the darkening have been developed. No discoloration has been observed on other softwoods.

1000 fbm of lumber is usually sufficient to maintain seasoning degrade to a minimum. On thick lumber and on boxed-heart pieces, somewhat greater quantities of urea may be required.

There are four general methods by which urea may be applied to lumber:

Dry-Spreading Method. The solid crystal urea is spread on one face of green lumber with the application heaviest at the ends of the boards and along the "broad-leaf" portion of the face where the grain is flattest and checking most likely to occur, Fig. 3. It is preferable to place the flat-grained green board with the sap or ring side up, and to apply the urea to this face. If the moisture content is low, it may be necessary to wet down the surfaces of the boards before applying the urea. After applying urea, the lumber is bulk-piled for about 1 day per inch of thickness before stacking for drying.

Bulk-piling has been found necessary on species in which the green moisture content is low, in order to get the urea to dissolve in the wood and to treat the under side of the boards. With Southern cypress and species that have a high green moisture content, bulk-piling can be eliminated, since the urea dissolves on the lumber in strip pile and diffuses or creeps around the sides and under side of the boards. This same effect can be obtained with other species by applying urea, strip-piling, and then steaming or exposing to high humidity in the kiln until the urea dissolves. The steaming period required will vary with the moisture content and density of the wood. With green oak and similar hardwoods, 2 to 4 hr at well above 80 per cent relative humidity and near 110 F are usually sufficient for absorption of the urea. With pine and other softwoods of relatively high green moisture content, 1 hr at 50 per cent relative humidity and about 150 F is usually ample. In treating pine and other woods by this method, flat-grain pieces should be stacked sap side up for best results.

Soaking Method. The green lumber is soaked in a saturated or near-saturated solution of urea in water for a period of time which is dependent upon the species of wood and its dimensions.

Dipping Method. The green lumber is dipped for 5 to 15 sec in a saturated solution of urea. For rough lumber 2 in. thick, or less, a solution saturated at room temperature (approximately 50 per cent urea) has been found to apply about 40 lb of urea per 1000 fbm in a 10-sec dip.

For lumber thicker than 2 in., it may be necessary to use more concentrated solutions, obtained by saturating at more elevated temperatures, in order to apply 40 lb or more of urea per 1000 fbm on the lumber.

The maximum rate of absorption of urea takes place in the first few seconds of the dip. After 15 sec, the rate of absorption is so slow that a soak treatment is required to apply appreciably greater amounts of urea.

Spray Method. The spray method, involving spraying the green lumber with a saturated solution of urea, can also be used to treat large items such as poles. The equipment consists of a relatively low-capacity pump, a make-up tank for urea solution, a spray head, and a shallow trough placed under the wood being treated to return the excess urea solution from the spray to the make-up tank. The spray head may be a suitable length of 1-in. pipe drilled with a series of small holes along one side. Wood absorbs the same amount of urea from a spray as from an equal period of dipping or soaking in a solution of the same strength. Using a heavy spray, the under side of the wood is covered with urea solution, and the absorption is the same as on the upper side. Where suitable, this procedure can be used to treat wood stacked in strip piles.

Urea solutions may also be applied to the surface of lumber by means of a brush or by hand spray.

RESULTS OF TESTS AND MILL EXPERIENCES

Mill-scale treatments and tests have been conducted for more than three years by a number of Southern, Appalachian, and West Coast mills. Laboratory investigations and small-scale tests have been and are being actively pursued by the Forest Products Laboratory, the West Coast Lumbermen's Association, the Ammonia Department of the du Pont Company, and some university groups. Species studied in both laboratory and mill tests include: Douglas fir, Western hemlock, Sitka spruce, Western red cedar, Lodgepole pine, Canadian white pine, Southern pines, Southern tidewater red cypress, white and red oak, poplar, walnut, hickory, and maple. In addition to sawed lumber, urea is being applied to cedar, pine, and oak poles, pilings, and posts; white-oak staves and headings for cooperage; hickory handles; bobbin-and-shuttle stock, and similar items. Some of the results obtained may be briefly summarized as follows:

West Coast Species. The West Coast softwoods, Douglas fir, Western hemlock, and Sitka spruce are being treated with urea by more than two dozen mills. Many carloads of treated wood have been shipped. Application of urea has made it possible to meet recent demands for large sizes of thick, wide, clear lumber, kiln-dried to specified moisture content; items that could not ordinarily have been handled with the usual seasoning methods. Urea is usually applied by the dry-spreading method.

One item that has recently come into prominence in the National Defense Program is pontoon lumber, comprising clear and select structural grades in sizes from $2^1/_2$ in. $\times$ $12^1/_2$ in. to 8 in. $\times$ 10 in., with a specified moisture content not to exceed 19 per cent, and checking limited to four moderate surface checks well distributed and not more than $^1/_2$ in. deep. Mills attempting to produce this item were experiencing from 40 to 60 per cent loss due to checking. When these mills adopted the urea treatment, losses from checking were reduced to from 1 to 5 per cent, and the drying time in the kiln was materially shortened. Drying schedules vary with the mill and the type of kiln used. In general, an initial temperature of 140 F, and a starting relative humidity of around 80 per cent have given satisfactory results. Final temperatures and humidities depend upon the species, dimension, type of kiln, and accompanying factors. For smaller sizes, a final temperature of 160 to 170 F has been used, with relative humidities around 50 to 55 per cent. For larger sizes, the final temperatures and humidities have been around 160 F, and 55 to 70 per cent.

In one test, nine pieces of Douglas fir 12 in. $\times$ 30 in. $\times$ 45 ft, seven of which were boxed-heart, were treated with urea and placed in a school building. No checks developed for 8 months. Summer weather caused an open check at one end of a boxed-heart piece and slight or hairline checks on the other boxed-heart pieces. Neither of the two side-cut pieces showed checks.

Mills have reported such results as: Less than 5 per cent degrade in drying 60,000 fbm of clear Douglas fir $3^1/_2$ in. $\times$ $7^1/_2$ in. to $6^1/_2$ in. $\times$ $7^1/_2$ in.; about 3 per cent degrade in 3-in. $\times$ 12-in. vertical-grain Douglas fir, compared to 20 per cent degrade in untreated lots; in 4 days dried 40,000 fbm Western hemlock to 13.5 per cent moisture content with no degrade, against 22 per cent moisture with 15 per cent degrade in the same time without treatment; select hemlock structural stringers 8 in. $\times$ 16 in. $\times$ 28 ft dried and shipped with no open checks; Western white pine dried in 5 days less time with 85 per cent reduction in degrade. A typical comparison of treated and untreated timber is shown in Fig. 1.

Urea is effective in preventing checking in Western red-cedar poles during air-seasoning. Small-scale tests have been completed, and a large mill test is under way. Urea is applied at the

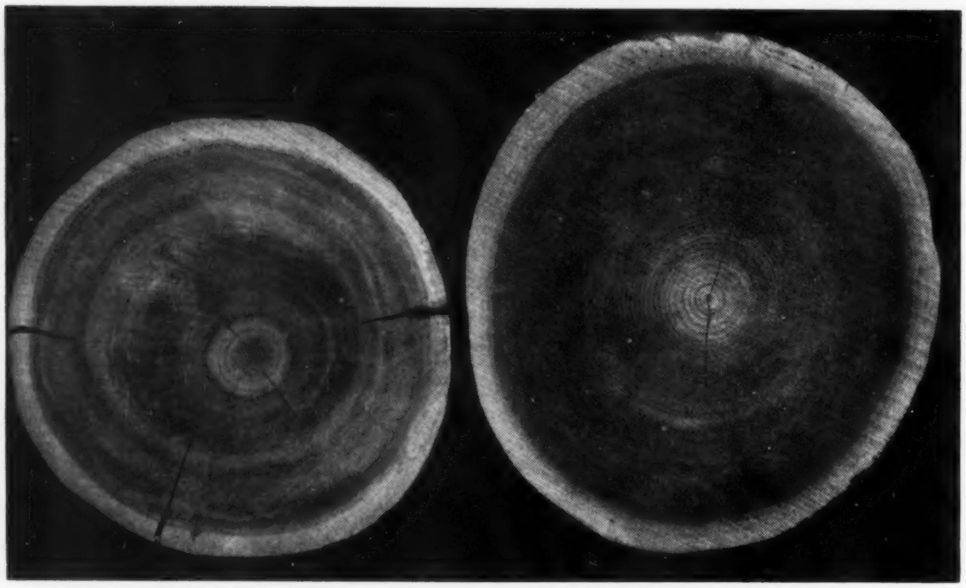

FIG. 2 SECTIONS THROUGH TWO WESTERN RED-CEDAR POLES
(Larger, 12-in., pole was treated by spraying the fresh-peeled green log 15 sec with saturated urea solution; smaller log, 10-in., was untreated. Both were dried under same conditions to 23 per cent moisture content.)

rate of 10 to 14 lb per 1000 fbm by spraying the freshly peeled log with a saturated solution any time prior to the development of checks. A 12-in-diam pole requires 0.09 to 0.13 lb of urea per linear foot, equivalent to a materials cost of about 12 to 17 cents, to treat a 30-ft pole. The urea requirements for larger or smaller poles are proportional to the cross section, Fig. 2.

Southern Cypress. Mill-scale treatment of Southern tidewater red cypress with urea has been in progress for more than 2 years, with most satisfactory results. Cypress of No. 1 common grade and better can be profitably treated with urea.

Fresh-sawed green cypress contains, even in the heartwood, from 160 to 200 per cent or more of water, based on the dry weight of the wood. Because of this, urea placed on the surface of green cypress is rapidly absorbed into the wood, and no bulk- or solid-piling is required.

It is estimated that the labor and handling costs of applying urea to cypress is less than 15 cents per 1000 fbm. As the chemical cost is about $1.75, the total cost is less than $2 per 1000 fbm.

On kiln-drying rough FAS grade 2-in. cypress to a moisture content of about 10 per cent, the normal degrade to select, and to shop, and No. 1 common grades is from 18 to 25 per cent. At average fob mill prices in 1940, of $108 per 1000 fbm for the FAS grade, and the select, shop, and No. 1 common grades valued at about $80, $72, and $53 per M, respectively, this degrade represents an average loss of $9 per M. With the urea treatment, the loss is reduced to from 0 to 4 per cent, resulting in an over-all saving of some $7 per M on this item. In addition to this, the lumber which remains on grade contains fewer seasoning defects. At one mill, the use of urea increased the average value of the lumber in some grades from $5 to $25 per M.

On an item such as 4-in. tank stock, not only is the value high (about $145 to $150 per M), but the degrade of untreated lumber is much more severe. Recently about 100,000 fbm of 4 in. random width and 22-ft length cypress tank stock were treated with urea and dried with no observable seasoning degrade. The prevention of checking represented a saving of $50 or more per M fbm.

In a test, two lots of 4-in. cypress of the same green grade were selected. One unit was treated with 40 lb of urea per 1000 fbm, and the other left untreated. Both piles were placed in the yards in December, 1939, under similar drying conditions. In September, 1940, the average moisture content of both lots was down to 16 per cent, and they were again graded. The treated stock was as originally piled, select and better grade, while the untreated lot had checked sufficiently to lower the grade to shop and better grade.

Oak and Other Hardwoods. Because of their greater tendency to check and honeycomb, hardwoods present a more troublesome problem than the drying of most softwoods. Certain species of hardwoods such as overcup oak are particularly refractory. The most satisfactory method of treating hardwoods and particularly oak is to apply the urea to the green wood, strip-pile the lumber, and place it in the kiln without intermediate air-drying. The initial conditions of the kiln should be above 82 per cent relative humidity at near 110 F, for dimensions up to 8/4, while for heavier dimensions the initial humidity should be maintained above 86 per cent. This high humidity is maintained until the moisture content of the wood is down to about 40 per cent of its dry weight. The period required will vary with the moisture content, density, and dimensions of the wood. The subsequent kiln schedule can be much more severe than for untreated lumber and very low relative humidities are safe.

The preferable method of applying urea to green oak is by soaking, especially for thicknesses of more than 6/4. The green lumber is submerged in a saturated or near-saturated solution of urea for a period of 2 to 4 or more days per inch of thickness, depending upon the dimension, as well as the nature of the wood. For oak less than 2 in. thick, urea may also be applied by dipping the rough-sawed green wood in solutions of urea, saturated at room temperature or at higher temperatures. The amount of urea employed is from 40 to 60 lb per 1000 fbm for oak less than 2 in. in thickness, and about 100 lb of urea on wood 2 in. or greater in thickness, Fig. 3.

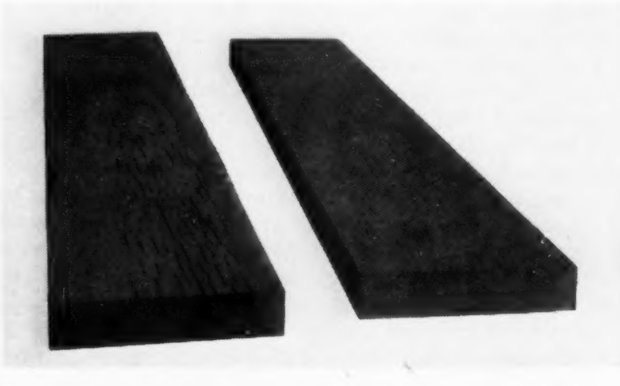

FIG. 3 MATCHED WHITE-OAK BOARDS $2^1/_2$ IN. THICK, UNTREATED AND UREA-TREATED, AND KILN-DRIED UNDER SAME CONDITIONS
(In untreated board, note checking and splitting along wide grain and little or none where grain is vertical.)

Tests have recently been completed on white-oak staves and headings for use in cooperage, and mill-scale tests are in progress. The results show that it is possible to kiln-dry green white-oak staves without intermediate air-seasoning in 2 to 3 weeks to from 12 to 14 per cent moisture content, without checking or honeycombing (hollow horning). The treatment comprises dipping the green wood for a few seconds in a solution containing about 50 per cent urea. One pound of urea will treat about 25 standard staves.

FIG. 5 THIN, 1/16-IN., SECTIONS OF MATCHED 5-IN-DIAM YELLOW LONGLEAF-PINE LOG, UNTREATED AND UREA-TREATED, AND DRIED UNDER SAME CONDITIONS

(Photographed by transillumination, illustrating large number of fine and usually invisible checks in untreated piece. Treatment consisted of urea solution spray on fresh-peeled green log, applying about 60 lb urea per 1000 fbm or about 5 lb per 8-in-diam 30-ft pole.)

The present practice without urea treatment is to air-season the staves for from 90 to 120 days down to about 20 to 25 per cent moisture content and then kiln-dry in from 7 to 10 days, depending upon the type of kiln employed. It is frequently impossible to air-season for 3 months or longer, and partially air-seasoned stock is kiln-dried. Untreated stock air-seasoned 1 month requires about 1 month in the kiln.

The urea treatment not only results in a remarkable saving in time, but eliminates the air-seasoning operation with attendant handling costs. It also eliminates the need for keeping a yard inventory and markedly increases the plant capacity.

No entirely satisfactory method has yet been developed for materially reducing checking and splitting of thick-dimension oak under air-drying conditions.

In general, the treatment of other hardwoods is similar to that for oak. Tests have been made or are in progress on maple, hickory, ash, poplar, beech, birch, cherry, gum, walnut, and other species. Urea treatment is applicable to items such as dowels, shuttles, bobbins, handles, woodenware, and the like, Fig. 4.

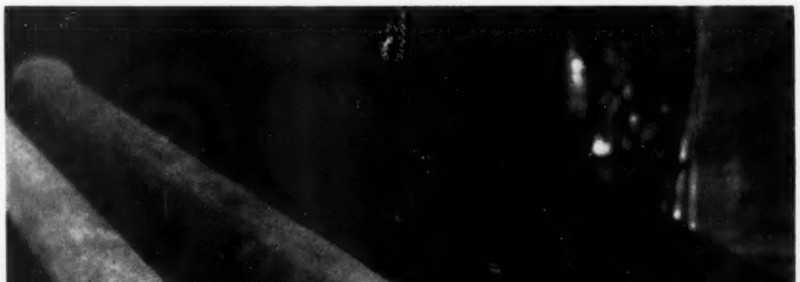

FIG. 4 HICKORY PICK HANDLES, UNTREATED AND UREA-TREATED, KILN-DRIED FROM AN AVERAGE MOISTURE CONTENT OF 53 PER CENT TO 16 PER CENT UNDER SAME CONDITIONS

(Treatment consisted of dipping green wood 15 sec in urea solution saturated at 105 F; average absorption of urea was 1 lb per 21 handles.)

Southern Pines. Chemical seasoning with urea is readily applicable to high-grade Southern yellow pines, and permits drying schedules as much as 50 per cent shorter than those now in commercial use.

Mill-scale tests on dense clear 8/4 North Carolina pine resulted in a product remarkably free from checks. Similar tests on Alabama pine also gave excellent results.

In the kiln-drying of pine, it is the practice to load lumber of various dimensions and apply the same schedule to all dimensions. Thus, the thicker lumber will come out with a higher moisture content than the thinner stock. This practice may also be followed when urea is used. The schedule can be made more severe, so that the time can be materially shortened, or the stock dried to a lower moisture content in the same or possibly less time. With urea-treated pine, the initial conditions in the kiln should be about 45 to 50 per cent relative humidity and a dry-bulb temperature of over 150 F, preferably about 180 F for pine 2 in. or less in thickness.

Recently, urea has been applied to pine poles, such as are used for telephone and telegraph lines and similar purposes. Application of urea at the rate of 60 to 80 lb per 1000 fbm appears sufficient to maintain checking of air-dried pole stock to a minimum. This is equivalent to a cost of about 22 to 30 cents per pole of about 8-in. average diam and 30 ft in length, Fig. 5.

Urea is entirely compatible with all sap-stain-prevention chemicals now in use. It may be used in conjunction with them, either applying the urea to the wood after the lumber has been dipped in the fungicide or mixing the urea with the fungicide in the dipping vat at the green chain.

CHEMICAL-SEASONING ECONOMICS

In the application of chemical seasoning to lumber the major item of cost is that of the agent. The present price of urea in carload lots is $80 per ton at production point and certain ocean ports. Considering the average freight and storage costs to be about $8 per ton the cost of urea at the mill is about 4.4 cents per lb. The average application of urea to lumber is 40 pounds per 1000 fbm, bringing the chemical cost to $1.76 per M. The cost of application varies from essentially nothing on items requiring no bulk-piling to perhaps 75 cents per M, where handling costs are high and bulk-piling and repiling are necessary. The soaking and dipping methods of applying urea to lumber require but little hand labor, but do require the installation and maintenance of treating tanks.

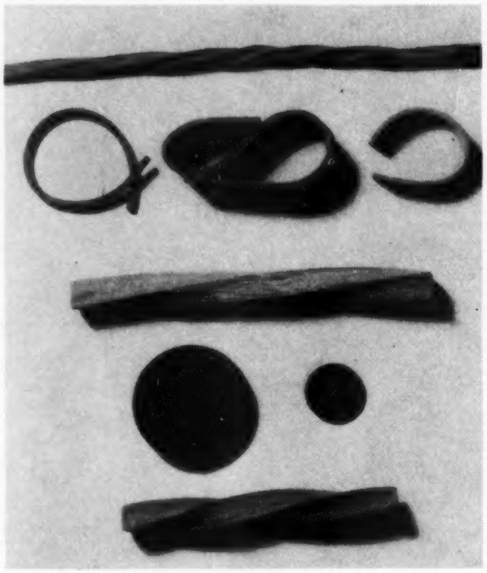

FIG. 6 BENDS AND TWISTS MADE WITH OAK IMPREGNATED WITH UREA, DRIED, AND HEATED

(The figure-eight-shaped sample was bent with the grain; the open loop to the right was bent across the grain; the large disk was laminated in pressing from small pieces; the small disk was made from blackjack oak sawdust. Shown through the courtesy of U. S. Forest Service, Forest Products Laboratory, Madison, Wis.)

The costs for treating some items, such as poles, may be from $^1/_3$ to $^1/_4$ of the costs cited, while for other items, such as thick oak dimension, the cost may be 2 to 3 times as great as that for treating the average lumber item.

The saving in the reduction of checking, splitting, honeycombing, trim losses, and such seasoning defects can be evaluated for any particular item. A greater proportion of the lumber being dried will remain on grade, and it will have a better appearance if chemically seasoned. The treatment is justified where the difference between the average values of the seasoned lumber, treated and untreated, is more than equal to the costs of treatment. Also to be taken into consideration is the fact that, in most instances, wood treated with urea can be kiln-dried more rapidly than untreated lumber of the equivalent dimension. The saving in kiln time and the consequent increase in kiln capacity can be directly credited to the treatment.

Chemical treatment may also be used to advantage on items which are shipped green and seasoned while in use or in transit.

WOOD BENDING

In the course of studies by the Forest Products Laboratory on the use of urea for chemical seasoning of wood, it was found that, when green wood, especially oak, is thoroughly impregnated with urea by soaking in a concentrated solution and then air- or kiln-dried, it becomes relatively plastic when heated briefly to about 210 F or higher. While hot, the wood can be readily bent, twisted, and compressed; and, if held in its altered shape until it cools, the wood retains this shape and resumes its normal rigidity and hardness. On reheating, the wood again becomes plastic. Thus, dry wood can be bent without resorting to the usual method of steaming and the subsequent drying of the bent wood. However, it is not necessary to dry the wood. Green urea-treated wood becomes much more plastic and flexible on steaming than does untreated green wood. However, the unique feature contributed by urea is that, if desired, dry wood may be bent with ease. Wood made thermoplastic through the use of urea lends itself to forming a variety of shapes more intricate than heretofore possible, Fig. 6.

While several hardwoods and softwoods appear to respond to plasticizing with urea, walnut, maple, and several varieties of oak are especially adaptable to this treatment.

When severe bends are to be made, it may be necessary to use a strap on the tension side of the bend to reduce the possibility of tension failure in the wood.

Much greater penetration and quantity of urea are necessary in the bending process than in the chemical-seasoning process. In chemical seasoning, only the outer shell of the wood need be penetrated, the quantity necessary for this being about 40 to 100 lb per 1000 fbm. For bending wood, on the other hand, the quantity of urea required is in the neighborhood of 15 to 25 per cent of the dry weight of the wood, or roughly 400 to 800 lb per 1000 fbm.

The Forest Products Laboratory has also found that urea-impregnated wood shavings, chips, or sawdust, when subjected to elevated temperatures and pressures, can be molded as a thermoplastic resin with a density approaching that of the basic wood fiber. These compositions and wood, treated with sufficient urea to allow it to become thermoplastic, are practically nonflammable.

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WHITE BURLEY TOBACCO

What the Engineer Should Know About Its Production

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IN THE art of producing tobacco, trends are developing in which the engineer soon will find himself intimately involved. Research at several institutions in the tobacco-producing areas is pointed in that direction. Each institution is most concerned, of course, with the type of tobacco grown within its particular region. The Kentucky Agricultural Experiment Station is in the center of the White Burley region so it naturally is most interested in the development of this type. Soil management and crop rotation, the breeding of desirable strains, the control of diseases and insects, studies in marketing, are subjects for research constantly engaging the interests of specialists in these fields. By helping to furnish machinery and supplies, facilities for housing, and transportation, the engineer indirectly is concerned with all phases of this program. There is, however, a particular phase which bids fair to bring the heretofore nonagricultural engineer closer to the farm. This is the process known as the curing of tobacco.

The method of curing used in a given region is peculiar to the type of tobacco grown in that region. Thus tobaccos are sometimes classified according to the method of curing, such as the flue-cured tobacco of Virginia and the Carolinas, the fire-cured tobacco of western Kentucky and Tennessee, and the air-cured types of Maryland and Kentucky.

White Burley is an air-cured type. Air-cured tobacco is defined by the Agricultural Marketing Service of the United States Department of Agriculture as "tobacco cured under natural atmospheric conditions without the use of fire, except for the purpose of preventing poleburn (house burn) in damp weather" (10).[1]

What are "natural atmospheric conditions?" The Kentucky Agricultural Experiment Station recently has undertaken to answer this question. Since 1936 experiments have been in progress, one of the objectives of which has been to determine the most "natural" or optimum conditions for curing White Burley tobacco. The engineer should be interested in these experiments because to make the best use of the results, mechanical equipment of several types will be required, fuels for heat and power, and redesigned curing barns containing perhaps features of a mechanical type that will be new and strange when compared with present structures. Independently of institutional assistance, and without scientific or engineering information, a few farmers already have begun to experiment, and crude installations of fans and ductwork, pipe coils, and furnaces already have been made. These experiments have attracted attention, ingenuity has been whetted, and the movement is gaining momentum. The mechanization of tobacco curing is certain to come, just as surely as the tractor, the combine, the cotton picker, rural electrification, and everything that the latter is making possible on the farm are realities today. Therefore, there are things related to tobacco culture about which the engineer should know.

For the five-year period 1935–1939, the average annual production of Burley tobacco in Kentucky was 218 million pounds (3). The tobacco was sold at an average price of 21.5 cents per pound, thus producing for Kentucky farmers a gross annual income of 47 million dollars, nearly 40 per cent of the cash income from all farm sources. During these years the production of Burley amounted to 76 per cent of the production of all types of tobacco grown within the state, and about 17 per cent of the production of all types grown within the United States.

Since Burley is a relatively high-priced tobacco compared with other types grown in Kentucky, the percentages based on farm value are higher than those based on quantity. For the five-year period, Burley accounted for 88 per cent of the income from all types in Kentucky; this was about one fifth of the income from all types grown within the United States.

White Burley is a thin, light tobacco with a mild flavor and is used in the manufacture of cigarettes and pipe and chewing tobacco (1). As a cigarette tobacco it ranks second in importance only to the flue-cured tobacco of North and South Carolina, southern Virginia, and Georgia. Owing chiefly to the popularity of the cigarette, the demand for Burley has increased in recent years. Except for annual fluctuations Kentucky acreage and production, however, have not changed materially during the last twenty years, and the increased demand appears to have been met by expansion of the growing areas into surrounding states, notably Tennessee, southern Ohio, southern Indiana, and western Virginia. Nevertheless, Kentucky production still accounts for more than 70 per cent of the White Burley grown in all of the producing areas.

TOBACCO CULTURE

Tobacco culture (1, 4) begins in the spring with the sowing of seed saved from a previous crop. The young plants are very tender, are subject to a number of devastating diseases and to injury by insects, and are easily overrun by weeds. For these reasons the seeds are sown in beds carefully selected for location and especially prepared by sterilizing and fertilizing the soil. To protect the young plants from cool weather and some insects the beds are framed with boards and covered with a white cloth commonly sold as "tobacco cotton."

In fact, the successful culture of tobacco, from the time the seed is sown until it is sold on the market, is a battle won against disease, insects, and the elements. With the meticulous preparation of the seedbed, the battle begins almost with the formality of a ritual; no farmer is certain of the outcome until the tobacco reaches the warehouse floor—indeed, not until he receives his check from the buyer. If $400 a ton for tobacco appears out of line with, say, $4 for a ton of coal, it must be remembered that coal was formed solely by nature and has only to be mined and delivered, while tobacco, on the other hand, is largely a man-made product, achieved by selection and breeding; and in order successfully to nurture the seed and deliver the final product to the market, the farmer must combat all of those destructive elements, a blessed consequence of which nature, on the first hand, has bequeathed to the miner. All of which is to say, that in the final accounting the farm laborer and the miner, or the large tobacco grower and the coal oper-

[1] Numbers in parentheses refer to Bibliography at end of paper.

Contributed by the Fuels Division and presented at the Fall Meeting, Louisville, Ky., Oct. 12–15, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

ator, stand about evenly compensated for their contributions to society. If anyone suggests, sardonically, that tobacco smoke is more injurious than coal smoke, or that tobacco is a luxury whereas coal is a necessity, one can reply that these are debatable questions, and whatever the decision, it is certain that, everything else being equal, if we had less of one we would also have less of the other.

It has been said that the soil of the seedbed needs to be sterilized. The purpose is to destroy weed seeds, insect grubs, and disease-producing viruses, bacteria, and fungi. In other words it is truly a process of sterilization. However, the method commonly used appears crude and consists merely of burning wood on the seedbed after the ground is broken. The wood usually is obtained on the farm and consists of brush, poles, old fence posts, discarded lumber, and similar items of otherwise no value and little use. There is no estimate of the amount of wood used for this purpose, and it is difficult to see how the commercial fuel producer can compete with this practice. Nevertheless, the availability of wood for this purpose is decreasing, and some other kind of fuel soon will be demanded. Also, in recent years some farmers have adopted the practice of steaming the tobacco beds, using a steam tractor or portable boiler as a source of steam. The steam is supplied to an inverted metal pan placed over the plant bed. About 100 sq ft of bed are steamed at one time for a period of 20 or 30 min. Steam does no better on the surface than burning, but the penetration to lower depths secured by steaming is an important advantage. For example, a comparative test using grubs as indicators showed that steaming killed all grubs placed in the soil to a depth of 10 in., whereas burning was effective only at depths less than four inches (5). The facts that steaming is better than burning and that some farmers already are using the method suggest that steaming will increase in popularity wherever a convenient source of steam is available.

Other tests have shown that for best results nearly two pounds of coal are required for steaming one square foot of soil by the inverted-pan method (9). White Burley acreage in Kentucky during the five-year period 1935–1939 averaged 265,000 acres (3). About 300 sq ft of seedbed are required to grow plants for setting one acre of tobacco. According to these figures, then, there is in Kentucky alone, and for this purpose only, a potential market for fuel equivalent to 80,000 tons of coal annually; and for the entire Burley-producing area, about 105,000 tons.

After the seed is sown a period of about eight weeks is required for the seed to germinate and develop into plants large enough to set in the field. The setting may be done by hand alone or with the assistance of a horse-drawn machine called a "tobacco setter." The growing season usually lasts from late in May or early June to late August or early September. During this period the tobacco requires several kinds of attention, the most important being cultivation, topping, and suckering. The purposes of cultivation are to loosen up the soil to retain the water of light rains and to destroy weeds. Topping is performed rather late in the season and consists of breaking off a portion of the top of the plant to prevent it from heading out or flowering and producing seed. The remaining leaves, usually 16 to 20 per plant, then tend to grow thicker and heavier and thus increase the yield. Suckering accomplishes the same purpose and consists of breaking off the shoots which form at the junctures between the leaves and the stalk. In recent years the demand for lighter leaves has increased and some farmers therefore purposefully attempt to regulate the weight of the leaves by using discrimination in topping and suckering, and also by changing the spacing of the plants in the field.

Harvesting the tobacco is a simple process; yet it requires not only a considerable amount of labor but also a degree of skill to avoid injury to the plants. The first steps consist of splitting the stalk to within a few inches of the ground, cutting off the plant at the ground, and then straddling the plants over sticks. The sticked tobacco usually is left in the field a few hours to wilt so that it may be handled easily without injuring the leaves. It is then hauled to a tobacco barn where it is cured and later prepared for the market.

Instead of splitting, a method called spearing is sometimes used. It consists of threading the plants upon the sticks by piercing a hole through the stalks a few inches from their butt ends. Harvesting by splitting or spearing is in contrast with the method called priming which is used in other regions and which consists of plucking individual leaves as they mature while the plants remain in the field.

TOBACCO BARN

The distinguishing feature of a Burley tobacco barn is in the arrangement of the interior framework. The barn is constructed of wood and the framework is designed to provide supports for holding the tobacco. Rails 10 to 16 ft long are supported by crossbeams fastened to posts, the number, height, and spacing of which depend upon the size of the barn. The rails are spaced four feet horizontally in order conveniently to support the ends of the tobacco sticks, and the vertical spacing also is usually about four feet. A well-designed barn should be not only structurally good but also it should contain an interior framework so arranged that the space available for the tobacco will be the maximum possible proportion of the total volume.

Tobacco sticks hold six to eight plants each and are spaced six to ten inches apart on the rails. The average length of a tobacco plant when cut and hung on sticks is about four feet, or the distance vertically between rails. Therefore, when a barn is properly and completely filled there is no room for anything else, not even standing room, although when artificial heat is used some of the lower rails may be left clear of tobacco to provide space for stoves and access for tending the stoves and inspecting the tobacco.

There are about 200,000 tobacco barns in Kentucky alone, and according to one estimate about 3000 barns are built new or remodeled each year. The entire Burley tobacco crop is usually cut within a very short period. A barn rarely serves two crops in a single season. Consequently, in a bumper year barn space is sometimes scarce and any available building—hay loft, implement shed, cattle barn, loose-leaf floors, garages—even the attics of homes—will be utilized if necessary. Such use of other space is possible, of course, because Burley is an air-cured tobacco.

A genuine tobacco barn, however, has characteristics other than roominess. Nearly every barn has ventilators in the side and end walls, while more modern barns have in addition either a continuous-ridge ventilator in the roof or a number of separate circular ventilators. The side ventilators are spaced about six feet apart and are made simply by hinging single boards used for covering the sides of the barn. They are sometimes painted a distinguishing color.

By adjusting the ventilators the farmer attempts to control the conditions inside the barn. In general, if the weather is favorable the ventilators are opened to fully ventilate the barn; otherwise the ventilators are closed to protect the tobacco from adverse conditions. Actually, the problem is not so simple. When to open the ventilators and when to close them are questions to which hardly any two farmers would give the same answer. At best, it is a most unsatisfactory system, as anyone connected with the air-conditioning industry might well imagine. Nevertheless, the ventilators do serve a useful purpose, and a barn or other building that does not have adequate

ventilation, either purposeful or by infiltration through cracks, is not a proper place to cure tobacco.

It is obvious that any recommendation for improving curing methods must take into consideration not only the "technique" of curing but also the investment in the numerous barns now standing and the shortage of space which occasionally occurs. For example, a proposal calling for a large diffusion space such as is frequently provided for processing rooms in some industries would almost certainly be rejected. With barns constructed and loaded as they are at present, the balancing of diffusion temperature, air supply, and diffusion space, to continue the example, is an irrelevant problem, for the simple reason that the space does not exist. Forced circulation would permit closer spacing of the tobacco and thus might compensate for space usurped for other purposes; but a failure in automatic control or an interruption in the source of power would almost certainly result in losses, including the manufacturer's prestige.

CURING, STRIPPING, AND SORTING

The curing of tobacco is not merely a matter of drying or conditioning. Curing is a process managed by the tobacco grower before the tobacco is delivered to the market and it must not be confused with "sweating," "redrying," "casing," or any similar steps incident to the manufacture of tobacco products.

During the early stage of curing, the tobacco plant, altough parted from its roots and its source of nutrients, is yet a living organism. Chemical changes characteristic of vegetation continue; there is both respiration and a redistribution of materials between the leaf and the stalk and between different parts of the leaf. The plant is not dead and curing does not stop until these changes cease.

The changes proceed at a rate largely determined by the prevailing temperature and relative humidity (2). When there is no control over these conditions, there is no control over the quality of the final product. If the means for control are available and properly used, the quality of the cured leaf may be kept within desirable limits, except, of course, that no characteristic can be produced which was not potentially within the tobacco when it was harvested.

Chiefly because of the presence of bacteria and fungi, cured tobacco will undergo further changes unless the moisture content is kept below the threshold of activity for these organisms. The tobacco hangs in the barn until the time comes for stripping the leaves from the stalk and preparing them for the market. Therefore, it is important, especially in damp weather, that the conditions within the barn be carefully watched during this latter period.

Tobacco will lose by evaporation of its water content 85 to 90 per cent of its initial weight before it reaches equilibrium with a normal atmosphere. In air-curing there is no distinct border line between curing proper and drying, and the process is not considered complete until the tobacco is thoroughly dry—that is, until it no longer loses weight in a normal atmosphere. In this sense the word "normal" cannot be distinctly defined, but it means chiefly a relative humidity that would cause the tobacco to "feel" dry and which would keep the tobacco in good condition indefinitely. In this connection, relationship between the feel of cured tobacco and relative humidity may be described as follows: Above 90 per cent cured tobacco is wet and soggy. Between 80 and 90 per cent it may be said to be in "high case." Between 75 and 80 per cent the case is satisfactory for stripping. At 70 per cent the tobacco can be handled without much breakage. Below 60 per cent it is brittle (2).

The preparing of tobacco for the market involves an important operation called "stripping" (4). Stripping consists of detaching the leaves from the stalk, sorting them into different grades, and tying leaves of the same grade into small bundles called "hands." A hand of tobacco will contain two or three dozen leaves of a given grade bound together by wrapping another leaf around the stems near their butt ends.

The hands go to the market; and as an example of how little things count, if the hands are not neatly tied with the ends of the stems even, a basket of tobacco will not have a good appearance and is likely to sell below its true value.

Before tobacco can be stripped it must be in proper case for handling without breakage (4). In Kentucky the Burley market opens early in December. If the weather preceding the opening is dry, farmers have difficulty in getting the tobacco stripped. This is a critical period. Prices are usually higher during the first few weeks of the market than later (6) and most farmers like to have their tobacco on the market early. While curing of some sort will take place in any kind of weather, a few days of humid weather at stripping time is absolutely essential. Caught in a dry spell, some farmers resort to whatever artificial means they can command to get their tobacco in case, such as hauling water to sprinkle barn floors and using steam from a tractor or steam and water together in a mixing device. The majority of the farmers, however, are dependent upon the weather, and in the absence of good stripping weather one of the most successful methods is to be on the alert for an early morning dew, under which circumstances enough tobacco sometimes may be taken out of the barn, bulked down or covered up with canvas, to keep a crew of strippers busy the remainder of the day.

One central-Kentucky grower has equipped his stripping room with modern air conditioning for keeping his tobacco in case, thereby making himself in this respect independent of the weather. The same grower also has installed a "daylight" lighting system which makes him independent of the sun too, and permits his strippers to do a good job of sorting in a full working day in spite of clouds and dusky late afternoons.

GOVERNMENT GRADING

Fine distinctions between proper and improper curing of tobacco will always be a mystery to anyone who does not have some appreciation of the grading and marketing of tobacco.

When the farmer delivers the tobacco to the warehouse floor, he places separate grades of tobacco into sales baskets according to his own sorting, but the final judge of a grade or the quality of a grade is the buyer. The tobacco is sold at auction and the price bid reflects the buyer's opinion of the quality of the tobacco together with, it must be added, his companys' requirements of a given grade.

Sometimes a farmer may feel that his tobacco is better than the bid price indicates—not with respect, necessarily, to the market average for a given season, which may be determined by other factors, but with respect to the quality of his crop in comparison with other crops. Chiefly for this reason the United States Department of Agriculture has provided an inspection or grading service for those marketing centers that determine by vote that they wish to adopt it. Among the forty-two markets for Burley tobacco which were open in all states during the 1940-1941 season, sixteen used the government grading service (11). Briefly, the system works as follows: After the farmer has delivered his tobacco to the warehouse or market place, it is inspected by especially trained government graders who place on each basket tags bearing the symbol of the grade in which the inspector believes that the tobacco belongs. The tags are available for inspection by the farmer, the buyer, or anyone who wishes to see the result of the grading by the government experts. After the tobacco is sold, and usually by the following day, the Department of Agriculture publishes and posts on the warehouse floor the accumulated average price of every grade of tobacco sold to

that date. The farmer then has the opportunity of comparing the prices offered for the respective grades of his tobacco with the average prices for the same grades, and he has the option of accepting the prices or rejecting them and holding his tobacco for a later sale. In most instances the farmers are satisfied and resales run a small percentage of the total.

The system of grading used by the government inspectors involves three classifications (10). The first consists of assigning to the tobacco a descriptive designation signifying to which major "group" it belongs, such as leaf, tips, lugs, or flyings. The second classification consists of assigning one of the five "quality" designations—choice, fine, good, fair, and low. The third is a "color" classification in which the colors distinguished are buff or straw, tan, red, dark-red, and green. While these three groupings are usually sufficient, other qualifying designations called "special factors" may be used if it is necessary to indicate characteristics not otherwise accounted for.

Obviously, the *grade* of a given lot of tobacco means that it belongs to one of the numerous classes which may be devised by combining the characteristics listed under the major groupings. For example, a report (11) published by the Agricultural Marketing Service of the U. S. Department of Agriculture shows that for the 1940-1941 marketing season, and for those Burley tobacco markets designated by the Secretary of Agriculture for official inspection, which accounted for about 37 per cent of the Burley sold, there were 28 grades of leaf ranging in price from \$6.25 to \$26 per hundred pounds; 16 grades of tips ranging from \$5.50 to \$15.50; 20 grades of lugs, from \$8 to \$31; 17 grades of flyings, from \$8.75 to \$29; and six grades in the nondescript group ranging in price from \$4.75 to \$9 per hundred pounds. A summary of the prices and grades is shown in Table 1. In this table "group" designations have been eliminated by weighting the prices according to the amount of tobacco sold in each group, so that the table shows only the average prices according to quality and color. It will be noticed that the prices decrease in two directions: First, as the quality changes from choice to low; and secondly, as the color changes from buff through tan and red to green.

This table is revealing and suggests the questions: To what extent were these prices determined by the condition of the tobacco at the time it was harvested? To what extent were they determined by the atmospheric conditions which prevailed during curing? And to what extent would the prices have been altered if all of the tobacco had been cured under ideal conditions? It can be admitted at once that it is impossible to give satisfactory answers to these questions. Nevertheless, a discussion of a few pertinent facts should be elucidating.

However, in order to have a better view of the price situation, information of another kind is needed, such as that shown in Table 2. The figures in this table (6) are for the crop year 1937 when prices were higher than in 1940, but they will serve to illustrate an important point. The table shows the government-inspected tobacco of 1937 divided into three grade groups, high, medium, and low; the percentage of tobacco in each group; the weighted average price per pound; and the percentage of the total value.

Suppose, for example, that the figures in the second column be reversed so that the table would show 54 per cent high grades, 35 per cent medium grades, and only 11 per cent low grades. Applying the same prices per pound the total value of the crop would be increased 55 per cent. Assuming that the tobacco graded was representative of the entire crop, such a reversal of quality would have meant an increase of 31 million dollars in the value of the Burley tobacco grown by Kentucky farmers in 1937.

It would be ridiculous to assume that such an increase could be realized by any changes in methods of production that would shift the quality of half of the tobacco from the low-grades group to the high-grades group. Gross income realized upon such a large scale is determined by too many forces to be taken so naively. The most that could be predicted from this supposition is that prices would become adjusted so that the total value would be eventually the same as before. Any method dealing with totals and averages from this standpoint would be fruitless.

TABLE 1 PRICE IN CENTS PER POUND OF 1940 BURLEY TOBACCO CLASSIFIED BY "QUALITY" AND "COLOR"

	Choice	Fine	Good	Fair	Low	Nondescript
Buff or straw	....	29.5	28.0	25.0	20.2	...
Tan	27.4	25.4	20.8	17.3	13.1	...
Tan, special factor	....	....	18.1	14.6	9.8	...
Red	....	16.0	15.8	13.0	10.2	...
Red, special factor	....	....	11.0	11.1	7.4	...
Dark-red	....	....	10.9	8.9	7.2	...
Green	....	....	8.8	8.9	7.0	...
Nondescript	....	....	....	....	....	6.4

TABLE 2 RELATIVE VALUE OF HIGH, MEDIUM, AND LOW GRADE OF 1937 BURLEY TOBACCO

Grade group	Per cent of tobacco graded	Weighted average price per pound, cents	Per cent of value of tobacco graded
High grades	11	34.6	21
Medium grades	35	24.5	46
Low grades	54	11.3	33

On the other hand, it is proper to suppose that an individual farmer might profit materially by adopting methods of production that would raise the quality of his tobacco from a lower to a higher grade. He thus would be competing with members of his own group—and nothing could illustrate more forcefully than the range of prices shown in Table 1 that, in spite of government inspection and attempts at co-operation, competition among farmers does exist. Every farmer knows that adverse or improper conditions before, during, and after curing might so degrade the quality of his tobacco as to make it unprofitable even to deliver it to the market. He also knows that proper curing and handling of a well-grown crop will result in premium prices. The farmer is interested, therefore, in any new method, new equipment, or new use of fuels that will enable him to produce better tobacco. Moreover, he is interested in such things *now*, regardless of what might happen.

There is then, without question, a market for fuels, equipment, and services that can be proved valuable to the farmer for increasing the quality of his tobacco and hence the amount of his income. Until recently, however, there has been a lack of exact information such as would enable an engineer to formulate a plan or devise a system.

CURING EXPERIMENTS

In July, 1940, the Kentucky Agricultural Experiment Station published a progress report giving the results to that date of experiments started in 1936 and conducted by a plant physiologist to determine among other objectives the effect of temperature and relative humidity upon the final quality of White Burley tobacco (2). The experiments were performed in nine especially equipped chambers in each of which the temperature and humidity could be controlled independently (8). While it is too early to draw definite conclusions from this work, nevertheless certain results may be briefly pointed out because they bear upon the questions asked in connection with Table 1.

In the first place, experiments have demonstrated that given a good crop of tobacco at harvest time, the tobacco *may* be cured in such a way as to produce a low-valued product, that is, it may be made to come out dark-red or green (Table 1).

Green tobacco, or tobacco with a greenish tinge, is produced if the humidity is too low at any temperature, and is most readily produced if both temperature and humidity are low. Red tobacco is produced if the humidity is too high, especially if the temperature also is high. In other words the lower or less valuable grades of tobacco are produced when the conditions tend to run to upper and lower extremes. This suggests, of course, that there must be intermediate conditions which would produce cured tobacco of the highest value. Although optimum conditions have not yet been determined for tobacco grown under various conditions of soil and weather, tentative conclusions relative to optimum conditions may be drawn. It appears that the control of humidity is much more important than temperature. That is, high-valued tobacco of a light-tan or buff color may be produced over a fairly wide range of temperature provided the relative humidity is maintained within certain limits. The optimum relative humidity appears to be about 65 to 70 per cent, while the temperature may be as low as 60 F or as high as 90 F (2). While no experiment so far has contradicted this tentative conclusion, yet in the light of other considerations it should be accepted with caution, as a more detailed study and understanding of Table 1 will reveal.

Let it be assumed, for example, that the color can be regulated by proper control of the atmospheric conditions. Then according to Table 1 it should be possible to start with tobacco which under certain conditions might be cured so as to be graded as fine red leaf priced at $16 per hundred pounds, but under other specified conditions it might be cured as fine tan leaf priced at $25.40 per hundred pounds. This would appear to be an improvement that would justify a sizable investment in mechanical equipment and accessories for automatic control.

In order for Burley tobacco to be graded as "fine" besides possessing other specified characteristics it must be "smooth, good in texture, oily, firm, medium in body, strong, true in color shade, and clear in finish" (10). If the conditions used to improve the color affect other characteristics such that the leaf becomes merely unrough instead of smooth, if it no longer has a good texture, if it loses its oily appearance, if it is no longer firm and strong, if the body is thickened, if the color shade is dusky instead of true, and if the finish appears dull instead of clear, then the tobacco would be graded not as "fine" tan leaf but as "fair" tan leaf and the improvement in price would amount to only 1.3 cents per pound. Furthermore, if the specified conditions produced cured tobacco of a tan color but with a dark color shade and if the finish appeared cloudy and dingy instead of only dull, the tobacco might then be graded as "low" tan leaf and the price thus might be reduced to $13.10 per hundred pounds.

In other words, it might have been better to have allowed that particular lot of tobacco to be cured *red* at $16.10 per hundred pounds than to attempt to improve its color. Or better, curing conditions might have been selected which would improve other characteristics besides color so as to raise the grade from fine red to choice red and thus secure some increase in price.

This example may or may not be true to fact. It is intended only to illustrate the complexity of the problem. That the problem is complex does not mean, however, that those in charge of this phase of the work have no hope of a solution. Such progress as has been made suggests that satisfactory results will be attained. Complete satisfaction will have been attained when a person instructed in the results of these experiments can inspect a crop of tobacco at the time it is harvested and prescribe curing conditions that will cause the tobacco to be sold at the highest price. Furthermore, since the quality of the final product necessarily depends upon the potentialities of the tobacco at harvest, it is conceivable that correlation of the results of curing with growing conditions may lead to new cultural methods which will make more likely those desirable qualities in cured tobacco which at the present time, if obtainable at all, are obtainable only under the most favorable curing conditions.

While it has been estimated that the plant physiologist in charge of this work has had already about 200 years' experience in curing tobacco—that is, it would take at least 200 natural curing seasons to duplicate the experiments performed in the laboratory—it is further estimated that he will require the experience of several more centuries before the effects of only the most important variables will have been mastered.

EXPERIMENTAL BARN

Despite the complexities, the results have been encouraging, and the Kentucky Agricultural Experiment Station is beginning to experiment upon methods for putting the results into practice. It is obvious that what will be needed most is a curing barn properly designed and equipped for housing the tobacco and for controlling the interior conditions. However, instead of rushing in to design and equip a structure that would be too revolutionary and possibly even too impractical for adoption, it has appeared wise to experiment first with the conventional barn with the hope that relatively simple and inexpensive methods may be found which will be at least a worth-while improvement over present methods. For this purpose an experimental barn has been built and will be ready for use during the 1941 curing season. The barn itself is of conventional design but it has been equipped with instruments that will make possible a rather complete survey of the temperature, humidity, and air motion within the barn, while other instruments have been provided for records of outside weather conditions.

Experience gained from this work no doubt will lead to an entirely new perspective from which the problem may be attacked directly in the light of current knowledge of air conditioning and with less regard to traditional practices. Plans designed from the latter point of view are in a formative stage, but their materialization probably will await the results of the preliminary investigations. In the meantime the field is wide open to experimenters and aggressive enterprisers.

USE OF FUELS

As already stated, air-cured tobacco is defined as tobacco cured "under natural atmospheric conditions, without the use of fire, except for the purpose of preventing poleburn." Poleburn, or house burn, is "a rotting of the leaves caused by an organism which seems to be always present on tobacco, but which becomes active only when relative humidity is high" (1). Therefore, when a farmer uses heat solely to prevent house burn, the immediate objective is to lower the relative humidity below the danger point. Technically, this is a feasible method because of the wide range of temperature within which good curing is possible (2).

In recent years a few farmers have used artificial heat even in ordinary weather and the practice is increasing in popularity. This is explainable by the fact already demonstrated in the laboratory that a relative humidity only moderately higher than the optimum will cause red or dark-red tobacco. Thus, a small amount of heat may be used to lower the humidity to the optimum range and thus make more likely cured leaves having the prized buff or light-tan color.

While the indiscriminate use of heat has been on the whole beneficial, there have been instances where the function of heat has been misunderstood and more damage than good has been done. For example, believing the purpose of heating to be to raise the temperature, some farmers have kept their barns closed tight, thereby raising the humidity and making the conditions worse than they would have been if no heat had been used.

The chief source of heat used by the Burley tobacco farmer is by-product coke. The coke is burned in a stove constructed on the principle of the "salamander" and consists of a sheet-metal drum provided with grate bars near the bottom and a flat or conical sheet-metal deflector over the top. Manufactured stoves are neatly built with means for regulating the draft, have adjustable deflectors, and cost the farmer about $7.50 each. Many farmers, however, make their stoves from old oil drums and similar containers. The average price of a home-made stove is about $1.50 (7).

The number of stoves used in a barn of a given size varies with the practice of the farmers. An average is one stove for each two-thirds acre of tobacco (7). On this basis it would require about 350,000 stoves to cure the Burley tobacco crop with artificial heat. The method of using the stoves consists of placing them on the dirt floor of the barn, spacing them according to the size of the barn and the number of stoves available, and then regulating the fires to produce the temperature the farmer believes to be necessary. The firing period may last 10 days, more or less, depending upon the weather and the condition of the tobacco.

In recent years the cost of coke delivered to the farm has been about $8 per ton. As to the amount needed for a given quantity of tobacco, a rough estimate, confirmed in part by a recent survey, is that nearly one pound of coke is required per pound of cured tobacco (7). At this rate, the potential market for coke for curing Burley tobacco amounts to 140,000 tons annually, or approximately the yield from 200,000 tons of coal. Probably not more than one tenth of this amount is used at the present time. Adding the amount already estimated for steaming seedbeds, the potential market for coal for all purposes for which fuel is used today in producing Burley tobacco is about 305,000 tons. There is a trend in this direction, but one probably would be overoptimistic to assume that half of this market would materialize within the next ten years even under the pressure of an intense sales campaign.

Charcoal is another fuel used in curing tobacco. Of the amount used, manufactured briquettes compose by far the greater proportion. One estimate places the amount consumed in a normal season at about 60 carloads, which would be equivalent to about 900 to 1000 tons. The cost is about $35 per ton.

Charcoal may be burned in small holes dug in the earth floor of the barn. A stove is not needed, although some farmers may prefer to use containers such as might be made by removing the tops from old oil cans. Thus numerous fires may be spaced evenly over the entire floor of the barn and a more uniform distribution of a less intense heat may be obtained such as is impractical with present methods of burning coke. Since stoves are not required, and in spite of the higher cost per ton, the net cost of charcoal in isolated instances may compare favorably with the cost of coke (7), especially if the charcoal-burning farmer is inclined to "underheat" and otherwise avoid wasting fuel.

A third fuel which is used to some extent is petroleum coke. However, the supply appears to be limited and the gross amount used is insignificant in comparison with by-product coke and charcoal. Finally, a system using oil has been proposed, and it is understood that it has been used successfully in one tobacco-producing area, but there has been no report on an installation within Kentucky.

CONCLUSION

It is obvious from this discussion that in comparison with what might be done, the farmer's attempts to solve what is essentially a problem in air conditioning are indeed primitive. But this is not the fault of the farmer. It was not the farmer's fault that he did not have the internal-combustion engine or the electric motor long before these became available to him.

Air conditioning on the farm, not only for tobacco, but for other products too, awaits only the integration of available equipment, perhaps partially redesigned, into units suitable for farm use. The economy of such units, of course, must be demonstrated.

Since it is the price or value of a commercial product that is involved instead of comfort and convenience, it should be possible to ascertain the practicability of a proposal without costly experimentation.

If one thinks only of tobacco, the relatively short period in which equipment is needed looms realistically as a serious deterrent. The use factor would be low. For this reason it appears that what needs to be developed is a general-utility unit that could be used for a variety of purposes. For example, a combination consisting of a coal- or oil-burning furnace, a steam boiler, a heat exchanger (steam or flue gas or both), and a fan for supplying air (steam-, gasoline-, or oil-driven—perhaps electric motor), all properly proportioned and mounted upon a trailer (self-propulsion would not be necessary), could conceivably be used for curing tobacco and hay, for steaming seedbeds and for general sterilizing purposes, for drying corn and other grains, for combating frost in orchards, for occasional heating of certain farm buildings (an otherwise too expensive greenhouse might become practical if a source of heat is already available), for controlling incidental processes such as the decomposition of manure, for conveying and cleaning and separating materials, for spraying and humidifying, and so on. With such an integrated unit available, the farmer—than whom no one is more ingenious—would find plenty of jobs to keep it busy.

ACKNOWLEDGMENT

For source material the author is indebted to the authors of the publications listed in the Bibliography, and in addition he wishes to acknowledge the assistance of Russell Hunt, field agent in tobacco, Claude Rankin, federal tobacco grader, and Dr. W. D. Valleau, plant pathologist, of the staff of the Kentucky Agricultural Experiment Station.

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MODERN ELEVATOR PRACTICE

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I—HISTORY

THE increased building heights of recent years have been made possible only by the development of high-speed elevators. Steam-driven elevators were used commercially as far back as 1865, and were quite satisfactory for low buildings The hydraulic elevator was a later development and dates from about 1880. This early history was reviewed by Thomas E. Brown.[1] He credits the hydraulic elevator with having increased building heights up to the limit of brick bearing walls. With the advent of steel-frame structures, building heights have increased continually and the development of elevators has progressed until, at the present time, it is possible to build and operate elevators that would be suitable for buildings much higher than are practical, for economical and other reasons. Until the development of the electric elevator, the hydraulic plunger elevator became the accepted standard, and such elevators were installed in many buildings throughout the country, some traveling as high as 25 and 30 floors.

The electric elevator was developed between 1880 and 1890 and became quite common after the latter date. In its early form, its speed was limited by the type of control available, and the height of building in which it could be used was limited as long as the winding-drum machine was the only form available. With the advent of the traction drive and magnet-operated contactors, permitting remote control, the electric elevator rapidly superseded all other forms and is now the accepted standard.

The modern elevator is made up of the following main elements: (1) Hoisting mechanism, (2) safety mechanism, (3) hoistway and entrances, (4) elevator car, and (5) control and operating systems.

II—HOISTING MECHANISM

The early electric elevators used a hoisting machine, consisting of a drum upon which the hoist cables were wound and an electric motor to drive the drum through gearing. Worm gearing was used because of the relatively large reduction required between the motor and the drum, and because the need for extreme quietness of operation made this form of gearing well suited to the requirements. Fig. 1 shows the method of roping used with drum elevators.

The use of the drum machine was limited by the size of drum that could be installed above the hoistway and had the disadvantage in that a different drum was required for each height of building. It was subject to overwinding, and some serious accidents have occurred when overtravel limit switches failed to stop the machine which pulled the car into the overhead structure. In some cases the hoist ropes have been pulled from their sockets, allowing the car to fall. The hoist ropes are attached solidly to the drum, and the point of suspension on the drum travels from one side of the shaft to the other as the ropes are wound on and off. The rigid connection to the drum and the angular movement of the ropes have caused failure of the rope at the sockets from fatigue, resulting from bending and whipping action. This breaking of ropes at the socket has occurred frequently enough to bring about a recommendation that the ropes on drum elevators be resocketed at least once a year.

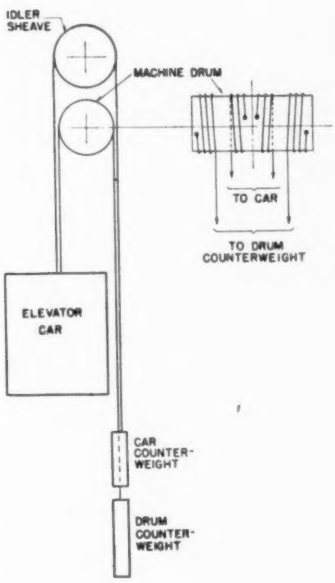

FIG. 1 DRUM-TYPE SYSTEM

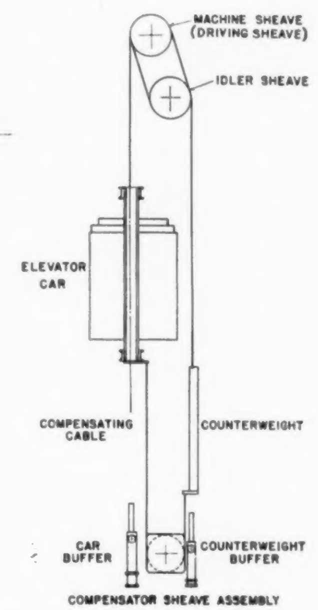

FIG. 2 DOUBLE-WRAP TRACTION SYSTEM (1-to-1 roping.)

Since parting of the hoist ropes on drum elevators is not an infrequent occurrence, the dependence of such an elevator upon its safety equipment is greater than that of modern traction elevators. The drum type is practically obsolete for new installations, but there are still a considerable number in service. Unfortunately, many of these equipments are 25 to 40 years old.

Modern elevators use the traction drive[2] which may be either geared or gearless. In this system of hoisting, the ropes pass from the car over the drive sheave and then to the counterweights, and the car is driven by the friction, or traction, between the rope and the sheave. The counterweight is made equal to the weight of the car plus approximately 40 per cent of the capacity load. An idler deflector sheave is usually used and, in some cases, a second wrap around the driving sheave is employed. The traction drive may be of two forms, (1) single-wrap formed groove, (2) double-wrap U-groove. Fig. 2 illustrates a double-wrap U-groove traction system. The grooves in the hoisting sheave are U-shape with a radius slightly larger than that of the cable.

In the case of single-wrap traction, the roping is the same except that the second wrap about the driving sheave is omitted and the grooves are formed in such a way as to increase the trac-

[1] "Passenger Elevators," by Thomas E. Brown, Trans. A.S.C.E., vol. 51, part B, 1904, pp. 133–186.

Contributed by the Committee on Machine Design, of the Machine Shop Practice Divison and presented at the Annual Meeting, New York, N. Y., December 1–5, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] The traction elevator was described fully in a paper "Modern Electric Elevators and Elevator Problems," by David Lindquist, Trans. A.S.M.E., vol. 37, 1915, pp. 705–745.

tion between the sheave and the rope. Fig. 3 illustrates the form of groove used with both single- and double-wrap traction machines.

Traction elevators are usually roped 1:1, as illustrated in Fig. 2, or 2:1, as illustrated in Fig. 4. With the 2:1 roped

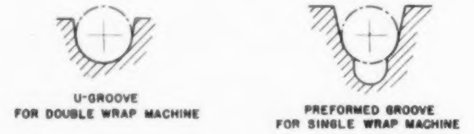

FIG. 3 CROSS SECTION OF TRACTION-MACHINE GROOVES AND HOIST CABLES

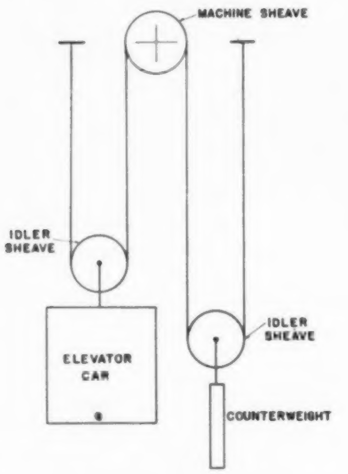

FIG. 4 SINGLE-WRAP TRACTION SYSTEM
(2-to-1 roping.)

elevator the car velocity is one half that of the periphery of the driving sheave, but the hoisting force at the point of attachment to the car is twice that of the 1:1 elevator. The 1:1 traction elevator, therefore, is most useful for high speeds and moderate loads, while the 2:1 system is used at lower speeds and heavy loads.

The traction elevator has none of the serious limitations of the drum type. Multiple hoist ropes may be used with a high factor of safety. The hoist ropes always operate in a straight line and breaking of the ropes is practically nonexistent. Danger of overwinding is overcome since, should the machine continue to overrun at the limits of travel, either the car or counterweight will rest on the bottom of the shaft, thus relieving the tractive force.

For high-speed elevators the gearless type of machine is used. This is really a large motor with the driving sheave and brake drum on the same shaft as the armature. Consideration of rope life dictates that the driving sheave should be made 40 to 50 times the diameter of the rope. With the minimum diameter of rope sheave permissible, it is not practical to use the gearless machine for elevator speeds much below 400 fpm. For this reason, the worm-gear type is the most suitable one for slower speeds. There is no particular limit to the top speed of elevators using gearless machines. The highest speed now in use, viz., 1400 fpm for the high-rise cars at Rockefeller Center, presents no problem as far as the hoisting mechanism is concerned, and even higher speed would be possible, although not practical, for building heights now contemplated. Fig. 5 illustrates a typical gearless elevator, and Fig. 6 shows a geared hoist machine.

An important element in the elevator hoisting mechanism is the hoist rope itself. It is a rather complicated structure composed of a number of strands wound upon a hemp center. Each strand is composed of a number of wires. The hemp center forms a support for the strands and carries lubricant. The various strands must move freely with respect to one another to prevent internal wear. The elasticity of elevator hoist ropes plays an important part in reducing the dynamic stresses encountered in elevator operation although this elasticity creates a few problems of its own.

Wire rope is manufactured in a great variety of constructions, depending upon the number of strands, the number and use of wires per strand, and the arrangement of wires in the strands.

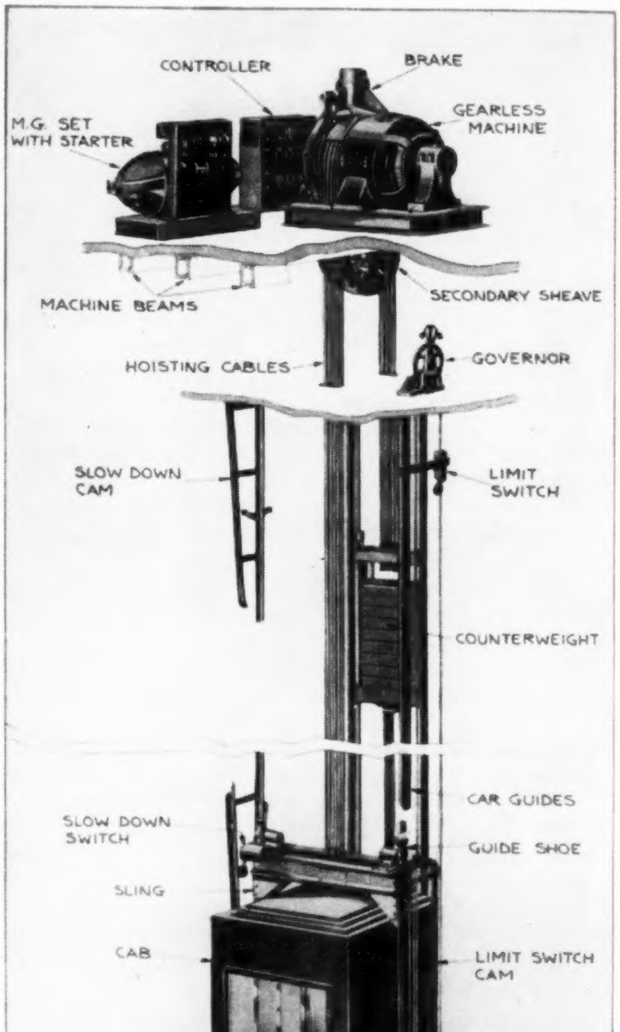

FIG. 5 TYPICAL GEARLESS TRACTION PASSENGER ELEVATOR

Only a few of these constructions are suitable for elevator use. In the interest of simplification the author would like to suggest that the two constructions illustrated in Fig. 7 will meet practically all requirements for elevator hoist rope.

III—ELEVATOR SAFETIES

For many years it has been the practice to equip the car with a safety mechanism located beneath the car platform which in case of overspeed, will grip the guide rails and bring the car to rest. This safety is actuated by a speed governor located overhead.

Elevator safeties may, briefly, be divided into two classes—instantaneous and sliding safeties.

In the instantaneous safety, a roller is brought into contact with the elevator guide rail and no sliding takes place except the minor amount due to the deformation of the dogs or the rail itself. Because of its severe stopping action the instantaneous safety is not suitable for speeds above 100 fpm.

Sliding-type safeties in a variety of forms have been used for many years and became necessary as soon as the rated speed of the car reached a value at which an instantaneous stop would become injurious to passengers.

FIG. 6 TYPICAL WORM-GEAR TRACTION MACHINE

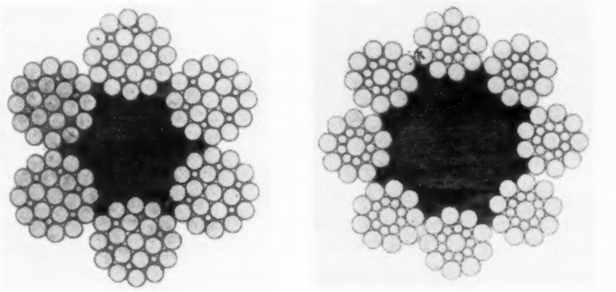

FIG. 7 TRACTION HOIST ROPES

(*Left*, Traction steel hoist ropes; 6 × 19 filler wire construction; 6 strands wound on hemp center, each strand containing 19 main wires and 6 filler wires. *Right*, Traction steel hoist rope; 8 × 19 Seale patent construction; 8 strands of 19 wires each wound on a hemp center.)

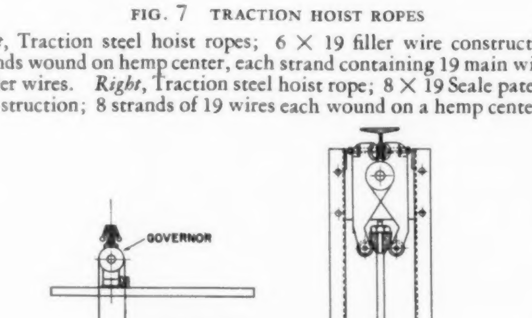

FIG. 8 (*left*) ELEVATOR SAFETY SYSTEM. FIG. 8*a* (*right*) WEDGE-CLAMP SAFETY (DETAIL OF FIG. 8)

Fig. 8 illustrates the operation of the commonly used wedge-clamp safety. When the car reaches a predetermined speed, the governor trips and its jaws grip the governor rope. This governor rope, attached to the car by means of a friction clamp, forms a continuous system that drives the governor. To this same friction clamp is attached a rope wound upon a drum beneath the car. When the governor trips, the governor rope is brought to rest, causing the drum rope to be unwound, thereby applying the safety jaws to the rails. The drum and wedge device is only one of the mechanisms used for actuating the safety jaws. In some designs a system of levers is used.

At the higher speeds, the most important characteristic of an elevator safety is that it shall bring the car to rest at a controlled rate of retardation that will not be injurious to the passengers. Since it is essential that the rate of retardation be kept within safe limits, it is necessary to design the governor jaws so that, when the forces acting on the rails reach a predetermined value, the governor ropes will slide through the governor jaws, no longer turning the safety drum, and the braking action then remains constant. As elevator speeds increased, controlled retardation became increasingly important.

The need for improved performance at higher speeds led to the development of the flexible guide-clamp safety. This type of safety differs from the standard wedge-clamp safety in that a set of springs is incorporated in the jaw structure so that, when the safety is fully set, the retarding action is determined by the adjustment or calibration of these springs. Fig. 9 illustrates a safety of this type. As in the case of the wedge-clamp safety, the drum operating mechanism is only one of the methods used for actuating the jaws.

A consideration of elementary mechanics indicates that, if retardation is to be kept within a safe value, the sliding distance must be proportional to the square of the rated speed of the car. This principle has not always been appreciated by code-preparing bodies and in some cases a fixed sliding distance independent of the car speed has been called for. Such a requirement calls for a high rate of retardation at high speeds, which, in some cases, is positively dangerous. This can be

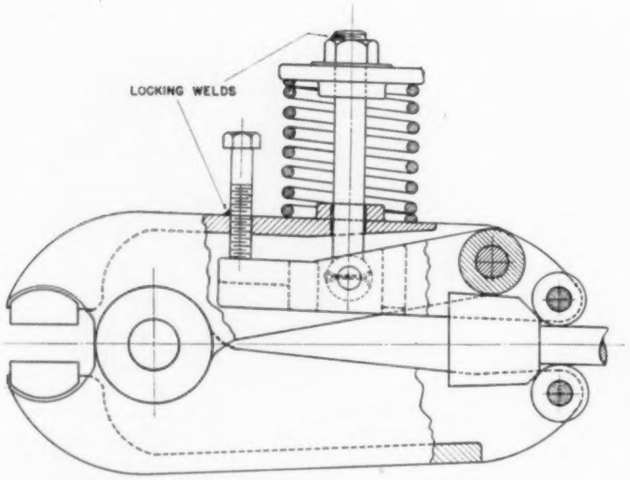

FIG. 9 FLEXIBLE GUIDE-CLAMP SAFETY JAW ASSEMBLY

appreciated when we consider that a rate of retardation equal to the acceleration by gravity doubles a passenger's weight and the stress on ankles and muscles. The importance of stopping the car smoothly from high speed and at a rate of retardation that will not be injurious to the passengers is evident.

While, in modern traction elevators, parting of the hoist ropes, which is the only condition that would permit a car to fall freely, hardly ever occurs, overspeed may arise from a number of causes. In the rare eventuality that the hoist ropes should break, the safety and governor are the last line of defense and the only means of preventing an accident. Therefore, broken hoist ropes is one of the conditions which must be taken into account in any analysis, and the safety and governor must be designed so as to protect passengers in case the hoist ropes break. Under runaway conditions, the car accelerates at a moderate rate, and when it reaches governor tripping speed the governor actuates the safety. Because the acceleration is relatively low, the car does not reach a speed greatly above that of governor tripping speed during the period of time that the governor and safety are getting into operation. With a freely falling car, however, the conditions are different. In this case, the car accelerates at 32.2 feet per second, and it is clear that a relatively small interval of time in governor action and distance traveled by the car in actuating the safety may represent a very dangerous increase in speed. For this reason the tripping mechanism of the governor should be designed so as to operate in a minimum of time, so that the governor jaws grip the cable as soon as possible after tripping speed is reached. It is also important that a minimum amount of tail rope be pulled out before the safety jaws are fully applied. This problem has been given careful study by the committee charged with the preparation of the American Standard Safety Code for Elevators. The latest revision of this code requires that not more than 30 in. of rope should be pulled out before the jaws touch the rail. Although this limit is quite stringent as compared with older accepted practice; nevertheless, it is too great to be permitted for high-speed elevators.

Every elevator should be equipped with terminal slowdown and stopping switches which will act independently of the operator to slow down the car and bring it safely to rest at the limits of travel. As an additional safeguard, suitable buffers are provided in the pit under both car and counterweight. In the early days of relatively low-speed elevators, spring buffers were developed for this purpose and have been used extensively in the past. Not appreciating fully the dynamic problem of stopping elevators, many code authorities permitted the use of spring buffers at car speeds beyond those at which they are really safe. Some local codes have permitted spring buffers at speeds as high as 400 fpm. When an elevator is brought to rest from high speed, the total kinetic energy of the car must be absorbed by the safety or at the terminal by the buffers. The design of a spring buffer to absorb the energy of a passenger elevator at speeds above 200 fpm is extremely difficult.

Buffers of the oil-brake type installed in the pit under both car and counterweight are so designed that the compression of a plunger forces oil through orifices which become smaller as the buffer is forced down and will retard the car at a controlled rate and absorb the kinetic energy of the moving car by heating the oil. The stroke of the buffer must be long enough to absorb the energy of the car and stop it within such a distance that the rate of retardation does not become excessive. The "American Standard Safety Code for Elevators" requires that the minimum total stroke shall be based upon an average retardation of gravity (g) and that the maximum rate of retardation shall not exceed $2^1/_2$ times gravity. The required stroke and length of oil buffers increase as the rated car speed increases. Such buffers have been designed successfully to operate at speeds as low as 200 fpm and can be built without excessive complications for speeds up to 900 fpm. While there is no inherent limitation to the length of the stroke of an oil buffer, the design becomes difficult for very long strokes. Auxiliary, terminal slowdown devices, the operation of which is independent of the normal terminal slowdown, and stopping switches combined with a buffer of shorter stroke have been used successfully at speeds above 900 fpm.

In practice, the design of both safeties and buffers to operate over the full range of load in the car becomes difficult. Since the safety must be designed to stop a free falling car when fully loaded, the rate of retardation may become excessive on running away with only one or two persons in the car. The practice of automatically holding down the compensating sheave at the bottom of the shaft when the retardation of the car exceeds gravity has the effect of adding to the mass of the car that of the counterweights, hoist, and compensating ropes, and the inertia of the driving engine and conpensating sheave. With the total mass increased, the variation in mass due to variation

FIG. 10 CONTROLLER FOR A VARIABLE-VOLTAGE-CONTROL, COLLECTIVE-OPERATION ELEVATOR

(The upper cabinet contains the floor and auxiliary relays and the floor selector. The lower cabinet contains motor generator starting contactor and main contactors for generator-field control.)

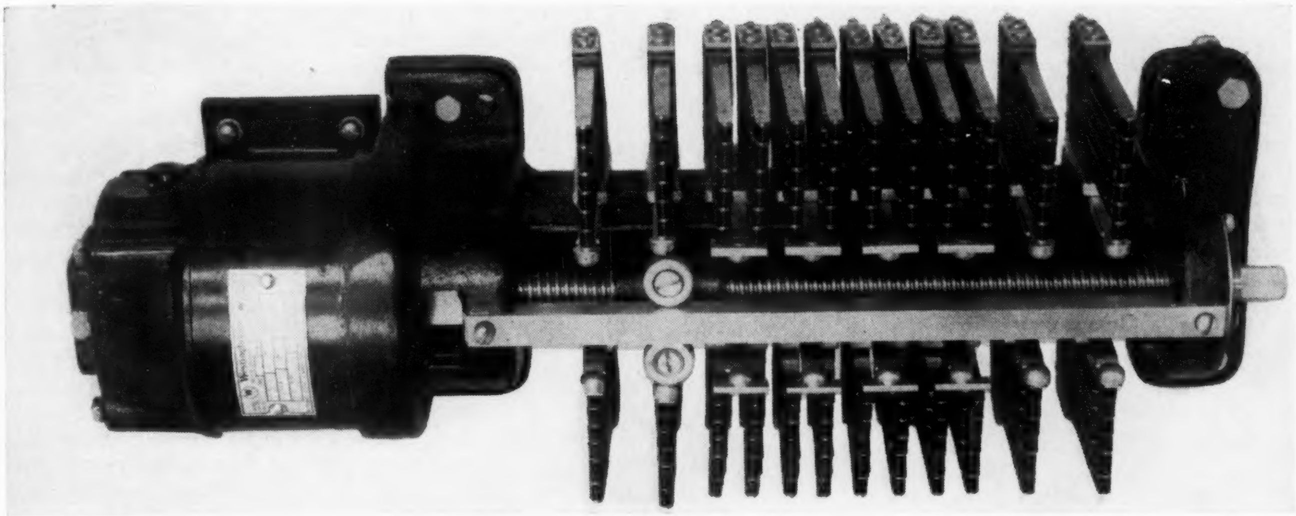

FIG. 11 FLOOR SELECTOR OF THE TYPE CONTAINED IN THE UPPER CABINET OF FIG. 10

(There is a row of contacts for each floor and the car position corresponds to the position of the rollers, which actuate the contacts corresponding to the floors. When a corridor button is pressed, a floor relay responds, and the selector contacts are energized. When, because of car motion, the selector roller closes these contacts, the stopping mechanism on the car is energized and the car stops at the floor.)

in load becomes less, and the rate of retardation of the car under all load conditions is more uniform.

IV—HOISTWAY CONSTRUCTION

The shaft or hoistway in which an elevator runs is as important to its safe and efficient operation as the elevator itself. The hoistway forms part of the building structure and contains the guide rails on which both the car and counterweight travel. The bottom of the hoistway, which is known as the pit, contains the overtravel buffers. The top structure must be designed with sufficient strength to support the machinery, weight of the car, counterweight, hoist and governor ropes, and other moving parts of the elevator. The beams and other structural parts supporting the machine should be designed for the static load of the machinery in the penthouse and for dynamic loading of the suspended car and counterweight. Guide rails must be in good alignment to insure smooth riding of the car. Since the building itself is an elastic structure, the rails cannot be attached solidly to high steel buildings. A construction that has been used successfully for high buildings is to attach the rails to their brackets by means of clips exerting a fixed spring tension on the rail, thus permitting the rail to slide through the clips to take care of building movement.

Elevators have demonstrated their usefulness in cases of fire, and for this reason good practice dictates that the enclosing walls of the shaft and the landing doors should be fire-resistant. In general, elevators have a very low accident rate, and the records show that the accidents have usually occurred at the entrances. The most frequently occurring accidents have been due to (1) the car moving away from the floor with the door open, (2) opening of hoistway door from the outside when the car is not at the landing. The first fault is prevented by an electric contact in the car control circuit to prevent car movement with the door open. The second fault is prevented by door locks designed so that the hoistway doors cannot be opened from the corridor side unless the car is present.

Complete protection is obtained when the lock and contact are so combined that the door must be both closed and locked before the car can be moved away from the floor. A device in which the lock and contact are so combined is defined as an "interlock." Practically all safety codes now require that passenger elevators be equipped with interlocks. A device in which the contact can be closed without the door being closed and actually locked is not a true interlock and should be designated as a "contact and lock." A contact and lock device is permissible on freight elevators operating at a speed of not over 150 fpm. Unfortunately, there is at times some confusion as to just what is meant by the two terms.

V—ELEVATOR CAR

The elevator car consists of a platform and supporting sling and the cab or enclosure. The guide shoes and safety plank are attached to and form an integral part of the sling. The cab is mounted on the platform so as to form an enclosure and its design is usually in harmony with the architecture of the building.

VI—CONTROL AND OPERATING SYSTEMS

The American Standard Safety Code for Elevators defines control as "a system of regulation by which the starting, stopping, direction of motion, acceleration, speed, and retardation of an elevator are governed."

This definition refers, therefore, to the system by which the motor itself is controlled. Operation is defined as a method of actuating the controller. The distinction between these two terms will become more evident when we refer to the systems of control and operation in general use. The methods of control in general use today are

1 Rheostatic control.
2 Two-speed alternating-current elevator control.
3 Variable-voltage (generator field) control.

The methods of operation in general use are

1 Car-switch operation.
2 Continuous-pressure operation.
3 Signal operation.
4 Dual operation.
5 Collective operation.

Rheostatic control is any system whereby the motor is controlled by a resistance in series with the armature of a direct-current motor, in the primary of a squirrel-cage alternating-current motor, or in the secondary of a wound-rotor motor.

When electric elevators were first developed, direct-current shunt-wound motors were used and all control was rheostatic. In a somewhat later period the high-torque alternating-current motor was introduced and has been extensively applied, both with wound rotors and with squirrel-cage rotors. For slow-speed elevators up to 100 fpm, a single-speed squirrel-cage induction motor is quite suitable as it is started by connecting either directly to the line or through one or more steps of primary resistance. Stopping is done entirely by a magnet brake, and there is no control of speed. As elevator speeds are increased, it becomes necessary to use a type of motor and system of control that will give a speed lower than the full speed, for making the final stop. The higher the car speed, the more refinement is required for both acceleration and retardation.

Direct-current motors of the gearless type, controlled by series and parallel resistances, were successfully used for speeds as high as 600 or 700 fpm. This system of control, however, has

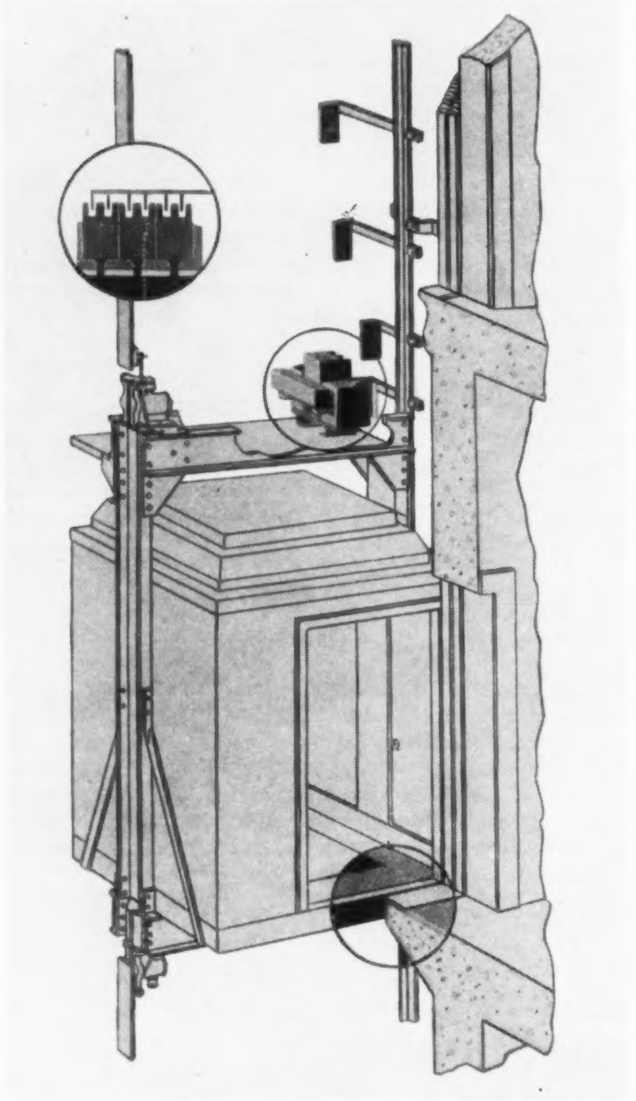

FIG. 12 INDUCTOR STOPPING MECHANISM MOUNTED ON THE CAR

(There are iron plates in the shaft corresponding to the floors. If, when the stopping inductor passes a plate its coil is energized, its armature moves and opens a contact which actuates the elevator controller to stop the car. If the car passes a stopping plate with the inductor coil de-energized, no stopping action occurs. The coil is energized through the floor selector contacts.)

some definite limitations in that the speed-control range is limited, and smoothness of acceleration is difficult to obtain because of the rate of change of acceleration that occurs when the starting resistance is short-circuited.

Variable-voltage control was introduced for elevator service in 1922 and is today almost universally accepted as the standard for high-speed elevators. This system employs a separate generator for each elevator, and the speed and direction of the car are determined by control of the generator field.[3] Since the introduction of variable-voltage control, elevator car speeds have been increased greatly, and refinements in control, not possible with the rheostatic system, have been developed. With rheostatic control, the gearless traction type of machine, which is inherently a direct-current motor, could be used only on direct-current power lines, and the maximum practical car speed was about 600 fpm. With variable-voltage control, elevator speeds have been increased, the highest yet installed being 1400 fpm, and the majority of high-speed elevators now operate on alternating-current power. Refinements have been made in variable-voltage control, the most important being the regulator system, whereby the speed of the car may be controlled over a wide range with close speed regulation. This development has made it possible to stop elevators automatically at speeds as high as 1400 fpm, the stop at the floor being within $^1/_2$ in. of the accurate floor level. The 1400-fpm elevators at Rockefeller Center are operating with a speed-control range of approximately 50 to 1.

VII—SYSTEMS OF OPERATION

The operation of the first electric elevators was by means of a hand rope in the shaft, that was grasped by the operator to start the car and to bring it to a stop. Later, magnet-operated contactors for starting and reversing the motor were developed, which were actuated by a master switch in the car, that became known as the "car switch." With car-switch operation, either rheostatic or variable voltage, the car is entirely controlled by the operator who initiates the stops and starts of the car by hand, stopping as accurately at the floor as possible and then moving the car by means of the car switch to the floor level. Further refinements have been made in car-switch operation. With one of the systems, known as "car-switch, self-leveling operation," the car is entirely under the control of the operator, who brings it to rest as near to the floor as possible, at which time the car, automatically and independently of the operator, levels itself with the floor. This system has been used extensively for passenger elevators but is particularly useful for freight elevators. With freight elevators, stretch of the hoist ropes during loading and unloading of the car may cause the car to move away from the floor level. With self-leveling operation, the car automatically returns to the floor if it moves away more than a predetermined amount. For freight elevators this accuracy is usually maintained within one quarter of an inch. This form of operation is particularly desirable where trucks are run on and off the car, because the car relevels itself after one pair of wheels has moved on or off, so that the car is perfectly level for the next pair of wheels.

For passenger elevators "car-switch automatic landing" has been used extensively. With this system the operator initiates stopping of the car by means of the car switch. After the operator has initiated the stop by bringing the car switch to the off position, the operation of the car becomes fully automatic and slows down and stops at the floor level.

Automatic elevators have been used for many years. The early push-button elevator was quite limited in its application.

[3] "Variable-Voltage Control System as Applied to Electric Elevators," by E. M. Bouton, Trans. A.I.E.E., vol. 43, 1924, pp. 199–219.

It was capable of answering but a single call at a time. While serving this call, buttons at all other floors were ineffective and had to be repressed after the car had completed its trip for the original call. When manually operated car and corridor doors were used, the elevator was frequently out of service because a passenger had left a door open. It is still used for special application, and the system is defined as "single automatic operation."

The development of "collective control" greatly increased the usefulness of the automatic elevator. With collective control a number of buttons, either in car or corridor, may be pressed and the car will automatically stop and answer each of these calls in succession as it travels through the shaft. With selective collective operation, or "two-button collective," an "up" and "down" button is located at each floor, and the car, while on the up trip, will answer only "up" calls and on the down trip will answer only "down" calls. With "nonselective," or "single push button, collective operation," there is only a single button at each floor, and the car stops at floors where buttons are pressed, irrespective of the direction in which the car is going. Thus it may stop for passengers who wish to go down as well as those who wish to go up, while making the trip. "Nonselective collective operation" is seldom used.

One of the most important characteristics of "collective control" is that it will store all calls registered even though the car has passed the floor on which the call was registered. In this event, the car will continue in operation to answer such calls, and in no case is it necessary to reregister a call once established. An up-going car need not always make the full trip to the top of the shaft but will automatically reverse at the highest registered call. It is also reversible in the same way when making a down trip.

A modern "collective control" elevator is equipped with some form of power-operated doors. The simplest form is a sliding car door, power-operated, and a swinging, spring-closing, hoistway door. This arrangement requires that the passengers open the hoistway door to get out of the car, but the doors are spring-closed so that they will not remain open and keep the car out of service. Many collective-control elevators are now being built with power-operated doors, both car and corridor doors being opened and closed automatically. An essential element in passenger-operated elevators is complete interlocking of doors and operating mechanism. Automatic elevators have been developed to a point where it is not unusual to operate two cars without an attendant on either of them. With such operation one car is arranged to remain at the ground floor to serve passengers entering the building. The other car, known as the free car, parks at the floor which was last served and is available to answer down calls. The car parked at the ground floor is automatically brought into service as traffic requires.

Collective-control elevators are frequently arranged for attendant operation at certain hours of the day and automatic operation at other hours. A suitable transfer switch changes the control from one operation to the other.

"Signal-control" elevators, developed about 1925, have now become the usual form for cars operating in banks. With this system, each car is equipped with buttons in the car corresponding to each floor, while in the corridor is an "up" and "down" button at each floor, connected with the entire bank. Passengers entering the car at the ground floor call their floors and the operator presses buttons corresponding to these floors, and on its up trip, the car will automatically stop at the floors registered. The corridor buttons register calls which are stored and are answered by the first car to approach the floor at which the call was registered. The elevator is attendant-operated, having a lever in the car which functions to start the car and close the door, but which has no effect upon the stopping of the car, this being fully automatic in response to both hall or car buttons. Such cars usually have power-operated car and corridor doors and automatic landing devices to stop the car accurately at the floor level. The opening of the doors may be synchronized with the landing of the car so that the door is fully open by the time the car reaches the floor level. The system is also called "full-automatic" operation, as both the selection of the car to be stopped and the actual stopping are accomplished automatically.

Accessory equipment in such elevator installations usually consists of "up" and "down" lanterns which light up as the car stops at the respective floors, a position indicator in the car to indicate at which floor the car has stopped, and position and motion indicators for each car in the ground-floor corridor. Dispatching systems are available to insure that the various cars in the bank leave the terminal at regular intervals. The type of dispatching devices and accessory equipment required is dependent upon the traffic conditions in the building.

VIII—ELEVATOR APPLICATIONS

Elevator applications are of two general types—passenger elevators and freight elevators. Freight elevators play an important part in material handling. Passenger elevators form an important link in our national transportation.

FREIGHT ELEVATORS

No satisfactory method of rating freight elevators in terms of capacity load and platform size has been evolved. For a given load in pounds the bulk of materials to be handled varies greatly and, consequently, platform sizes vary. Table 1 gives the characteristics and ratings of a group of freight elevators, that have been adopted by the industry as standard. The considerable range in platform size for a given capacity is evident. There are, however, many specials, and no attempt has been made at standardizing elevators larger than 10,000 lb capacity. In general, freight elevators operate at low speed and use geared traction hoisting machines, but there are special cases using gearless machines.

Continuous-pressure push-button operation is frequently

TABLE 1 FREIGHT ELEVATORS

Capacity and size		Control and operation		
Capacity, lb	Platform size	Speed, fpm	Control	Operation
2500	5'6" × 6'6"			
	6'6" × 7'6"			
		50	AC1S	CS or CB
3000	6'6" × 7'6"			
	6'10" × 7'9"		AC1S	CS or CB
		100	AC2S	CSL or PBSL
4000	7'4" × 9'0"		VV	CSL or PBSL
	8'4" × 10'0"			
5000	7'10" × 10'0"		AC1S	CS
	8'4" × 10'0"	150	AC2S	CSL or PBSL
			VV	CSL or PBSL
6000	8'4" × 10'6"			
8000	8'4" × 12'0"			
	8'10" × 12'6"	200	VV	CS or CSL PBSL
10000	9'4" × 14'0"			
	10'4" × 12'0"			

AC1S = Single-speed squirrel-cage motor across line starting or with step of primary resistance
AC2S = Two-speed squirrel-cage motor, pole-changing control
VV = Variable-voltage control
CS = Car-switch operation
CSL = Car-switch operation with self-leveling
PB = Single-push-button operation
PBSL = Single-push-button operation with self-leveling
CB = Continuous-pressure push-button operation.

used. In this system there is an "up" and "down" button at each floor which calls the car to the floor. The button must be held closed until the car arrives. A vision panel in the hoistway door makes it possible to see the car as it approaches the floor.

PASSENGER ELEVATORS

Passenger elevators have been divided by the industry into the following classes

1 Office-building elevators.
2 Apartment-house elevators.
3 Department-store elevators.
4 Hospital elevators.

Each of these classes is a distinct type characterized by its general arrangement or layout, its type and size of entrance, and its control and operating system.

For many years it was the practice to use 75 lb per sq ft as a basis for determining the rated capacity of passenger platforms. Experience, however, indicated that this figure was too low, particularly for larger cars. The number of people that will crowd into an elevator is more often determined by the size of the car than by its name-plate rating.

The 1925 edition of the American Standard Safety Code for Elevators contained a curve between area and load, which considerably increased the capacity of larger platforms. The subject was further investigated about three years ago, and the Code Committee adopted a new capacity curve.[4] The new curve established a method of rating passenger elevators that is a great improvement over the earlier method and more in line with the loads actually carried. Table 2 gives the capacity, platform size, and type of entrance for the different types of passenger elevators that have been adopted as standards by the industry. Fig. 13 illustrates typical door arrangements. Table 3 gives the car speeds, control system, and method of operation commonly used for these elevators. It must not be inferred that these tables are all-inclusive, for there are many special conditions to be met, and elevators are built that differ considerably from these standards. They do, however, represent a practice that has met with general acceptance.

The proper selection of elevators for a modern office building requires an analysis of the population of the building, its time of arrival and departure, the amount of interfloor traffic, and as much information as can be obtained regarding the kind of service the tenants will demand. The measure of "elevator service" is the number of passengers that a bank of elevators will carry during the period of maximum traffic, coupled with the time interval between the departure of cars, which affects the waiting time at the floors. For high buildings, it is customary to divide the cars into banks, each bank serving a particular group of floors. To determine the number of banks of cars, the floors to be served by each bank, and the number, size, and speed of the cars in each bank, it is necessary to make a complete calculation of the round-trip time of each car, including its running and accelerating time, door-operating time, and the passenger-loading time. The round-trip time, divided by the number of cars in the bank, gives the interval, and the number of passengers that can be carried is determined by the size of the cars and the number of trips that can be made in the required period of time. A considerable amount of judgment and experience is required to arrive at the best layout.

The modern elevator is much more automatic than those of a few years ago. This involves a great increase in the number and intricacy of the apparatus, but careful and skillful design of this apparatus has made elevators the most reliable and safest known means of transportation.

TABLE 2 PASSENGER ELEVATORS

Capacity, lb	Size	Net area, sq ft	Entrance Type[a]	Entrance Size
		Office-building elevators		
2000	6'0" × 4'9"	24.0	Center opening	3'0"
2500	7'0" × 5'0"	29.7	Center opening	3'6"
3000	7'0" × 5'6"	33.1	Center opening	3'6"
3500	7'0" × 6'2"	37.5	Center opening	3'6"
		Apartment-house elevators		
1500	5'9" × 4'0"	19.1	Single-swing	2'8"
			Single-slide	2'10"
2100	6'4" × 4'5"	23.2	Single-swing	2'8"
			Single-slide	3'0"
2500	7'0" × 5'0"	29.7	Single-slide	3'0"
			Center opening	3'6"
		Department-store elevators		
3000	7'6" × 5'3"	33.6	Center opening	4'4"
3500	8'0" × 5'6"	37.9		5'0"
4000	8'0" × 6'0"	41.7	Two-speed Center opening	5'0"
5000	8'6" × 6'6"	48.5		5'6"
		Hospital elevators		
3500	5'4" × 8'0"	38	Two-speed	3'8"
4000	5'8" × 8'4"	42.5	Two-speed	3'8"

[a] See Fig. 13.

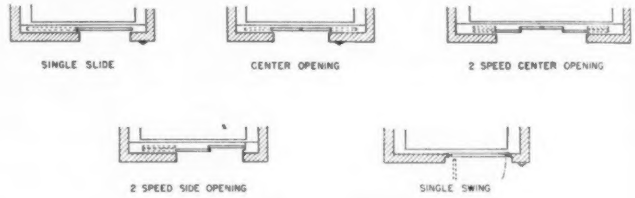

FIG. 13 TYPICAL ELEVATOR ENTRANCES

TABLE 3 PASSENGER ELEVATORS—SPEED RANGE AND CONTROL

Type	Geared Speed, fpm	Geared Control	Geared Operation	Gearless Speed, fpm	Gearless Control	Gearless Operation
Office-building elevators	100	AC1S	CS or PB or Col	400	VV	CS or CAL or FAC
	150	AC1S or AC2S	CS or Col	500	VV	CS or CAL or FAC
	200	VV	CS or Col or CAL	600	VV	CS or CAL or FAC
	300	VV	CS or Col or CAL	700	VV	CAL or FAC
	400	VV	CS or Col or CAL	800	VV	FAC
				1000	VV	FAC
				1400	VV	FAC
Apt.-house elevators	100	AC1S	Col	500	VV	CAL or Col
	200	VV	Col	600	VV	CAL or Col
	300	VV	Col			
Dept.-store elevators	200	VV	CAL	500	VV	CAL or FAC
	300	VV	CAL	600	VV	FAC
	400	VV	CAL	700	VV	FAC
Hospital elevators	100	AC1S	PB or Col			
	150	AC1S or AC2S	Col	500	VV	CAL or Col or FAC
	200	VV	Col	600	VV	CAL or Col or FAC
	300	VV	Col			
	350	VV	Col			

AC1S, AC2S, VV, CS, PB, see Table 1.
Col = Collective operation
CAL = Car-switch automatic-landing operation
FAC = Full-automatic (signal) operation

[4] MECHANICAL ENGINEERING, vol. 62, Feb., 1940, p. 163.

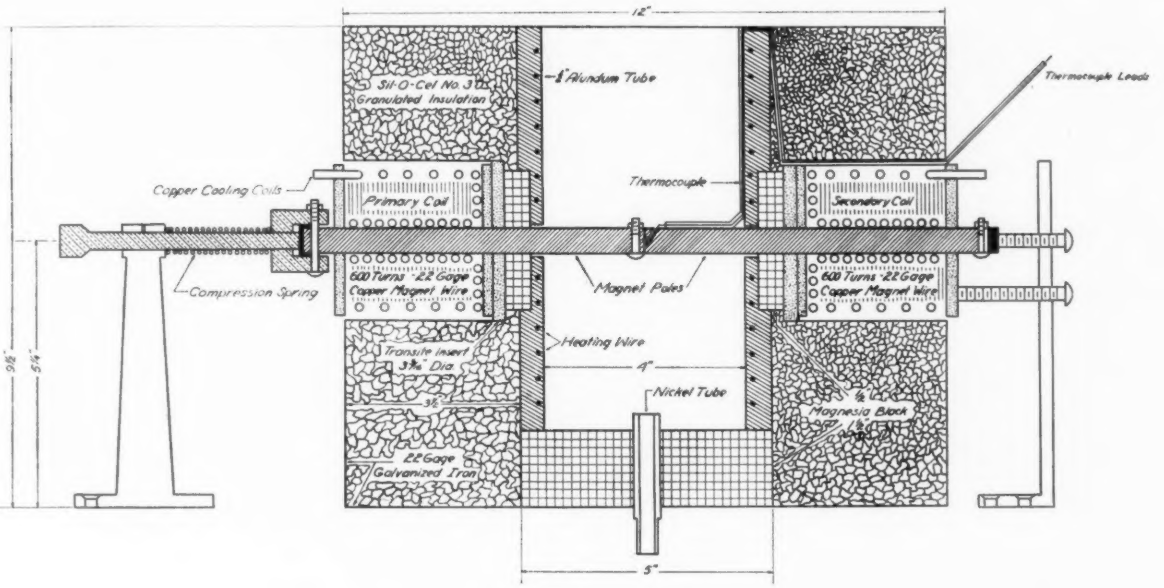

FIG. 1 FURNACE FOR MAGNETIC STUDY

HOT-QUENCHING *of* HIGH-SPEED STEEL

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As a result of a research[1] on the hot-quenching of 18-4-1 type high-speed steel, certain facts have been developed concerning the kinetics of austenitic transformation, as well as data on the hardness and toughness, resulting from various hot quenches.

Approximately 3 per cent is added each year to the manufacturing costs of high-speed tools because of crackage during hardening. In this investigation an effort was made to eliminate crackage stresses by decreasing the differential existing between the temperature of the quench and the hardening temperature.

High-speed steels have the unique characteristic of retaining their hardness even at a dull-red temperature. This hardness is attributed to martensite, with abrasion resistance added to the structure by the complex alloy carbides present in the matrix. Certain elements (tungsten and molybdenum in particular) impart stability to the martensite, thus preventing its softening at normal operating temperatures.

At the hardening temperature of 2350 F (slightly below the point of incipient fusion), the structure of the steel consists of an austenitic matrix, containing carbon, tungsten, chromium, and vanadium. In addition to these alloys, certain complex carbides of the elements are present which do not go into solution at the elevated temperature. Upon quenching the steel, the resulting composition is made up of high-alloy-retained austenite, high-alloy martensite, and the undissolved alloy carbides.

TYPE OF FURNACE USED IN INVESTIGATION

Austenite is nonmagnetic in nature. Martensite, a decomposition product of austenite, is magnetic in nature. This property, therefore, suggests the use of a magnetic analysis in following the austenitic transformation on hot-quenching. With this principle in mind, an electric furnace was constructed, containing a magnetic circuit for following this change.

Fig. 1 shows an elevation of the furnace used in following the austenitic transformation, which consists, primarily, of a heating element, a magnetic circuit, and a source of a neutral atmosphere. By means of an external resistance bank, the heat input to the furnace may be varied. Since excessive oxidation of the specimen would change the magnetic properties somewhat, a nitrogen atmosphere was provided to prevent excessive scaling. A chromel-alumel thermocouple calibrated against the freezing point of tin was embedded within $^1/_{64}$ in. of the secondary pole face.

The magnetic circuit utilized in the furnace is illustrated in Fig. 2. It consists of a primary coil, a secondary or pick-up coil, and approximately $3^1/_2$ ft of silicon transformer iron. A magnetomotive force is induced in the primary pole by means of

[1] This paper constitutes a brief résumé of a bachelor's thesis, resulting from a research, conducted in the Heat-Treatment Laboratory of the University of Illinois, Urbana, Ill., under the direction of Prof. K. J. Trigger.

Presented at the Semi-Annual Meeting, Kansas City, Mo., June 16–19, 1941, of The American Society of Mechanical Engineers, under the joint auspices of the Engineers' Council for Professional Development, and the A.S.M.E. Committee on Relations With Colleges. The paper received first prize at the Group V Midwest Student Meeting, Detroit, Mich., April 14–15, 1941.

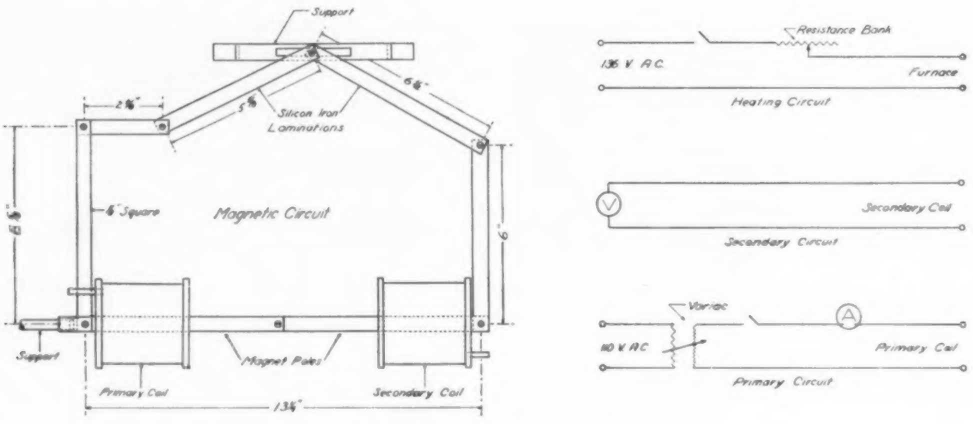

FIG. 2 CIRCUIT DIAGRAMS

the primary coil. The flux emanating from the pole passes through the specimens (placed between the pole faces) and is picked up by the secondary pole. An emf is induced in the seondary coil by the magnetic flux in the circuit. Readings of primary current and secondary voltage are obtained by suitable instruments located in the lines. The current input to the primary coil is controlled by means of a "variac" inserted in the leads.

Since the test specimen is located between the pole faces, the flux picked up by the secondary must pass through it. In order to keep magnetic losses constant, the same amount of flux was kept in the circuit throughout the entire research. A specimen structure composed primarily of austenite and, therefore, nonmagnetic, requires a greater primary current to produce the established secondary voltage of 7 v. Likewise, an increase in magnetism of the specimen, or a change to martensite, requires less primary current for set flux conditions. To summarize the furnace operation: A decrease in primary current shows a change in magnetism of the test specimen, which in turn indicates a transformation in structure from austenite to martensite.

CHECK TESTS OF EQUIPMENT

Fig. 3 represents a typical heating-cooling curve for the silicon-iron magnet poles. Very little change is noted in the input current up to 1250 F. At this temperature the current requirements increase until at 1335 F a marked increase is noted. The curve illustrates the magnetic change of the silicon iron, and indicates loss of magnetism at 1335 F. The iron-silicon diagram for a 3 per cent silicon iron fixes the magnetic change at approximately 1330 F. A similar test was conducted on a specimen of "A" nickel which is practically pure nickel. The two curves were alike in shape and character. However, the "A" nickel was found to lose its magnetism at 640 F—again within 5 degrees of the theoretical point of change. These two tests serve to illustrate the reliability of the furnace for both high and low temperature ranges.

The specimens used in the magnetic part of the study were $^1/_4 \times {}^3/_4 \times {}^3/_4$ in. pieces of 18-4-1 high-speed steel. Because of their low heat conductivity, they were preheated at 1650 F for half an hour. This treatment corresponds to commercial practice. After the required soaking, the specimens were transferred to the high-heat furnace held at 2350 F. This furnace was of the "globar" type equipped with a diamond block to reduce harmful oxidation. After $2^1/_4$ min at the hardening temperature the specimens were quenched in a molten bath.

Those specimens quenched above 625 F were quenched in a lead bath. Pieces quenched below the melting point of lead were immersed in a ternary alloy composed of lead, tin, and cadmium. The test specimens were quenched for 15 seconds, and immediately transferred to the magnetic furnace, which was operating at the temperature of the quench.

The specimens were held at the quench temperature for one hour in the magnetic furnace, and then permitted to furnace-cool. Readings of primary current were made frequently during the period at quenching temperature, and every 20 F on cooling. No change in magnetism was noted at the temperature of the quench which indicated that no isothermal decomposition of austenite took place during the hour held at that temperature. Cohen and Koh in an excellent study have observed that isothermal transformation of retained austenite at 1150 F requires about five hours to begin.

RESULTS OF INVESTIGATION

The curves showing graphically the austenitic decomposition are plotted with mid-temperature as the abscissa, and change in primary current (amperes) as the ordinate. For instance, with successive readings of 340 F and 320 F one co-ordinate of a point for the reading would be the mean temperature, or 330 F. The other co-ordinate would be the change in amperes between the two observed readings. The curves, therefore, are quite similar to inverse-rate curves. Since the curves represent change in current, the greater the difference

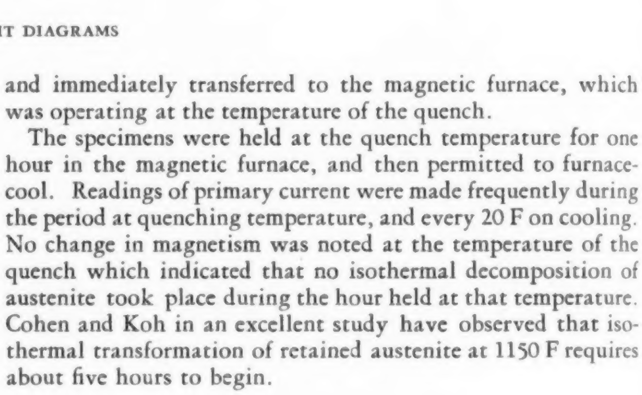

FIG. 3 HEATING-COOLING CURVE FROM MAGNETIC TEST
(Silicon-steel magnet poles; secondary 7v.)

between successive readings the greater the amount of austenitic transformation.

In Fig. 4 are illustrated the results of the 350 F and 400 F quenches. It is to be noted that in both instances the maximum transformation occurred at 310 F. For both quenches, most of the transformation occurred at a 100-deg range. The slopes of the resultant curves were rather abrupt, until the maximum

point of transformation occurred, after which the changes became more gradual.

The results of the 700 F and 900 F quenches are illustrated in Fig. 5. The curves are similar to those of the lower quenches, in that there is one pronounced point of maximum change. For the 700 F quench, the greatest austenitic decomposition was found to occur at 320 F. Increasing the quenching temperature to 900 F raised the change point to 330 F. The lower portions of the curves have the same characteristic appearance as do the low-temperature-quench curves. However, some austenitic transformation was indicated over the entire cooling range for both of these quenches.

The resultant curves of the 1050 F and 1150 F quenches, as illustrated in Fig. 6, depart in form from those of the lower temperatures. Instead of having one well-defined point of maximum breakdown, these quenches exhibit three points of considerable change. The points for the 1050 F quench were 550 F, 470 F, and 350 F. Those for the 1150 F quench

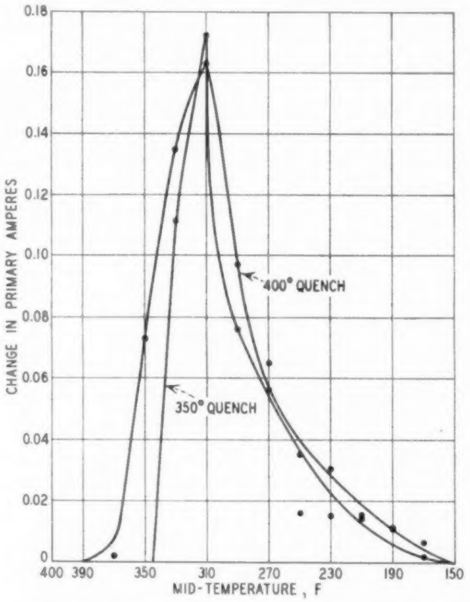

FIG. 4 AUSTENITIC TRANSFORMATION OF 18-4-1 HIGH-SPEED STEEL BASED ON MAGNETIC CHANGE; 350 AND 400 F QUENCHES

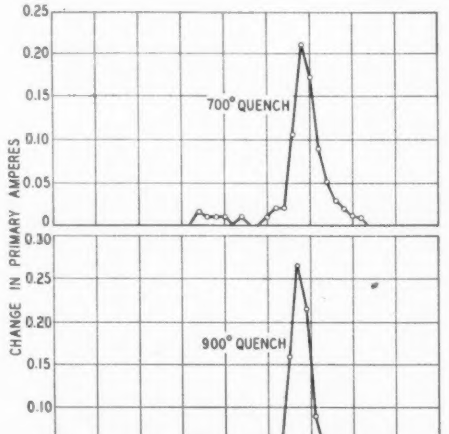

FIG. 5 AUSTENITIC TRANSFORMATION OF 18-4-1 HIGH-SPEED STEEL, BASED ON MAGNETIC CHANGE; 700 AND 900 F QUENCHES

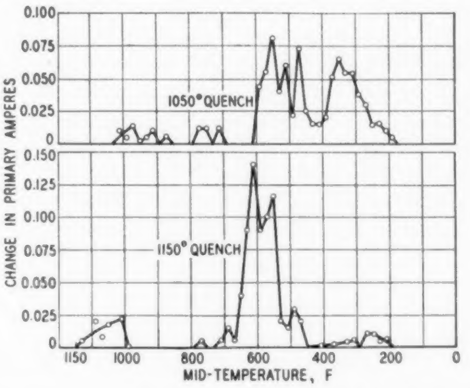

FIG. 6 AUSTENITIC TRANSFORMATION OF 18-4-1 HIGH-SPEED STEEL, BASED ON MAGNETIC CHANGE; 1050 AND 1150 F QUENCHES

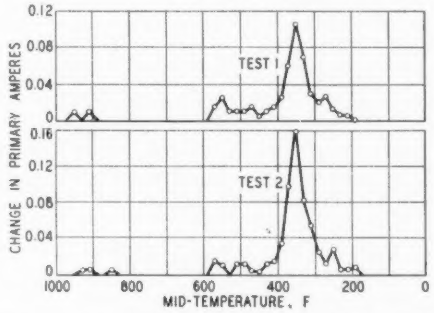

FIG. 7 AUSTENITIC TRANSFORMATION OF 18-4-1 HIGH-SPEED STEEL, BASED ON MAGNETIC CHANGE; 975 F QUENCH

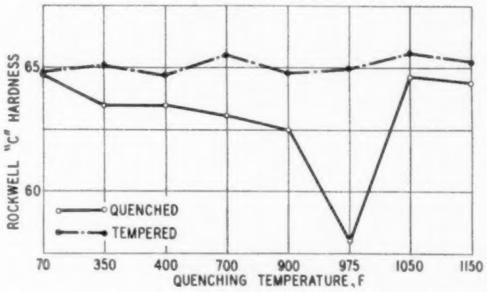

FIG. 8 QUENCHED AND TEMPERED HARDNESS OF 18-4-1 HIGH SPEED STEEL

were found to be somewhat higher, occurring at 610 F, 550 F, and 490 F. Again, as for the intermediate-temperature quenches, these curves indicate some transformation occurring over almost the entire cooling range.

In an effort to determine the line of demarcation between the two types of change, three tests were conducted at a 975 F quenching temperature. The information of two of the tests is plotted in Fig. 7. These curves show a similarity with the results of the lower temperature quenches. One pronounced point of change is located at 350 F, with some transformation, however, occurring at higher temperatures. Comparison of the two curves shows a marked resemblance, with almost identical changes occurring for each of the two tests. These curves illustrate the reliability as well as the reproducibility of the magnetic determinations, as followed in the laboratory.

The resulting Rockwell C (Rc) hardness of the as-quenched specimens is illustrated in Fig. 8. An oil-quenched specimen subjected to the same prequenching treatment as the other specimens was found to have a hardness of 64.7 Rc. Both of the specimens for 350 F and 400 F quenches exhibited a hard-

ness of 63.6 Rc. Increasing the quench to 700 F lowered the hardness slightly to 63.1 Rc. A Rockwell C hardness of 62.5 resulted from the 900 F quench. A very pronounced drop to a hardness of 58 Rc was noted on all three of the specimens quenched at 975 F. The hardness increased abruptly on the specimens quenched at 1050 F, and 1150 F, with readings of 64.6 Rc, and 64.4 Rc, respectively.

The effect of raising the temperature of the quench to 975 F is to decrease the quenched hardness. This is brought about by decrease in the amount of martensite present in the resulting structure. This was further substantiated by the extreme difficulty of etching the specimens with low hardness values. This is due to the fact that the high-alloy austenite is quite difficult to etch with the ordinary type of reagent. Above 975 F the increased hardness is attributed to the phenomenon known as "precipitation hardening." The alloy carbides formed above 975 F provide sufficient slip interference to contribute appreciably to the increase in hardness.

Cracks were prevalent in the test specimens quenched at 975 F and below. This resulted from the expansion of austenite to martensite in a matrix which was too rigid to accommodate the volumetric increase of martensite. Evidently, the austenitic transformation occurring above 350 F takes place in an austenitic matrix with sufficient plasticity to relieve the excessive crackage tendency. To substantiate this explanation the specimens quenched above 975 F were found to be free of cracks.

LATHE BREAKDOWN AND CHARPY IMPACT TESTS

In an attempt to determine the practical aspects of hot-quenching methods, a series of lathe breakdown tests and Charpy impact tests were conducted. The specimens for both tests were given the same prequenching treatment as those for the magnetic studies, and quenched at the same elevated temperatures. However, in addition, specimens for the physical tests were subjected to a commercial two-hour temper at 1050 F.

The lathe tests were conducted on $^1/_2$-in. lathe tools, cutting a section of railway axle. Failure of the tool was accurately denoted by means of a recording wattmeter. At failure, the tool began to rub the axle, resulting in an appreciable increase in input power. Based on the tests, a trend toward a slight decrease in tool life with an increase in quenching temperature was noted.

Investigation of the unnotched Charpy specimens indicated an increase in impact strength with an increase in quenching temperature. This change in impact is due to the fact that high-alloy austenite is relatively tough, as compared to martensite. The conclusions of the impact tests are in complete agreement with the magnetic studies and the hardness investigations. All three studies indicate a gradual decrease in the amount of transformed austenite as the quenching temperature is raised.

Hardness and impact resistance are both desirable qualities in a cutting tool. Impact resistance is particularly important under intermittent cutting conditions. Since the tool life resulting from the hot quenches investigated seems to be practically constant, toughness is suggested as the proper criterion for judging such treatments. Apparently, therefore, the 1050 F and 1150 F quenches are better for lathe tools.

CONCLUSIONS

General conclusions based on the investigation are as follows:

1 There are two modes of austenitic transformation, with the line of demarcation occurring somewhere between 975 F and 1050 F.

2 Increasing the quenching temperature up to 900 F decreases the amount of austenite transformed, therefore reducing the quenched hardness and increasing the toughness.

3 Precipitation hardening, occurring above 975 F, increases the as-quenched hardness.

4 There is a slight trend toward a decrease in tool life with an increase in quenching temperature.

5 The high-temperature quenches result in better lathe tools.

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PHOTOGRAPH OF HIGH-TEMPERATURE ELECTRIC ARC TAKEN BY A NEW METHOD
(The original is from an all-color training film by Raphael G. Wolff on "Inside of Arc Welding.")

AIR FILTERS *for* AIRPLANE-ENGINE PROTECTION

By WILLIAM K. GREGORY

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PLANS are being made at the present time to install intake air filters on the motors of virtually all training planes, bombers, and fighters now being manufactured for the U. S. Government. The experience of the British in their operations in the deserts of Africa and elsewhere has emphasized the importance of air-filter protection.

Even in the United States, severe engine wear has occurred at a number of air fields, particularly those in the South. When our air activities were limited to commercial planes and a relatively small number of Army and Navy planes which used well-paved runways, we had no acute dust problem; but with our expanding air force it has become more and more necessary to use temporary airports with unpaved runways. Planes taking off in formation generally use some of the unpaved portion of the field even where paved runways are available, and great clouds of dust are kicked up by the planes in the lead, which go into the engines of the planes following, unless adequate air-filter protection is provided. This obviously results in excessive engine wear and makes it necessary to overhaul and rebuild engines at frequent intervals, thus increasing the amount of maintenance required. Disregarding the expense of this maintenance, we are now confronted with a problem of production, and anything which can be done to increase the effective life of an airplane motor is virtually equivalent to increasing our production facilities.

SELECTING THE PROPER TYPE FILTER

The first step in the application of air filters to airplane engines is the selection of the type of filter to be used. Oil-bath air cleaners, which have been used with great success on trucks, tractors, and large stationary Diesel and gas engines, are ruled out immediately because of their size, weight, and the fact that oil would spill out in maneuvering the plane. Dry-type air filters, which employ felt or other fabric as filter media, are inflammable and require frequent replacement. During actual warfare, the replacement of dry-type filters would constitute a serious problem, as it would be necessary to provide cargo space for shipment and a dry place for storage. Another objection to dry-type filters is that they offer a high resistance to air flow and increase rapidly in resistance as dust is accumulated. For all these reasons, dry-type filters are considered unsuitable for airplane application even though some of them have been used with a certain degree of success by the British.

If the oil-bath and dry-type filters are eliminated from consideration, this leaves only the washable viscous impingement-type filter. Air filters of this type consist of metallic filter media mounted in channel frames and so arranged as to provide a tortuous path for the air passing through. This filter media is coated with oil, and when dust carried in the air stream strikes the oil-coated surfaces it is caught and held. A typical filter of this type, which is so designed that there is a considerable amount of space between the individual strands of filter media on the air-entering side and the density gradually increases toward the air-leaving side, is shown in Fig. 1. The purpose of this construction, which is normally referred to as "progressive packing," is to distribute the dust caught by the filter fairly evenly throughout the entire depth of the filter media and thereby provide maximum dust-holding capacity with minimum rise in resistance. Such a filter, if properly made, should last virtually as long as the plane in which it is mounted. It can be cleaned by washing in gasoline, and oiled by dipping in airplane-engine lubricating oil, both of which are readily available at any air base. The only additional equipment required for maintenance is a small supply of spare filter cells and suitable tanks for washing and charging the filters; so the transportation and maintenance problem of this type of air filter is reduced to an absolute minimum.

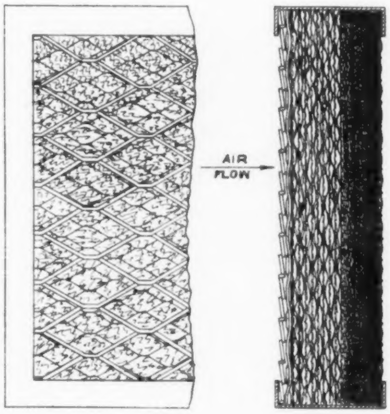

FIG. 1 TYPICAL WASHABLE VISCOUS IMPINGEMENT-TYPE AIR FILTER

RESEARCH CONDUCTED ON VISCOUS IMPINGEMENT-TYPE FILTERS

The development of a suitable viscous impingement-type filter, which provides maximum cleaning efficiency, maximum dust-holding capacity, and minimum weight and size, presented a very interesting research problem. The filtration of air is a rather new art and was started only 20 years or so ago, but during that time certain standard practices have developed in applying air filters to ventilating and air-conditioning service. For instance, it has been customary to limit the velocity of air flow through the free area of viscous impingement-type filters to a maximum of 350 fpm, and to make the filters approximately 4 in. thick. The resistance to air flow had to be kept low ($^1/_2$ to $^3/_4$ in. water gage when dirty), because the blowers used in ventilation service are incapable of overcoming high resistance, and filters had to have a sufficient dust-holding capacity to operate under normal dust conditions for a period of from 4 to 6 weeks before cleaning was necessary, in order to keep their maintenance cost within reasonable limits. In designing a filter for military airplane service, however, it was necessary to disregard standard practice for ventilating and air-conditioning service, and virtually start from scratch in an attempt to develop a thinner filter which would afford satisfactory protection at much higher air velocities, thereby reducing both the weight and the size of the filter unit. After consultation with various airplane manufacturers and government officials, the following fundamental specifications for airplane filters were established:

Contributed jointly by the Aeronautic and Oil and Gas Power Divisions and presented at the Fall Meeting, Louisville, Ky., October 12–15, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

1 Maximum permissible resistance when dirty, 4 in. water gage.
2 Minimum permissible efficiency, 90 per cent.

Having established these two limits, the performance of a filter, therefore, may be judged by the velocity of air flow and the amount of dust it is capable of accumulating before the resistance exceeds 4 in. water gage, or the efficiency drops below 90 per cent. As a general rule, the efficiency proves to be the determining factor, and most of the filters tested dropped below 90 per cent efficiency before the resistance reached 4 in. water gage.

With the idea of making a filter having the absolute minimum thickness, much of the original research was devoted to the development of a filter $^3/_4$ in. thick. Referring to Fig. 2, curves marked *A* and *B* indicate the performance of two of the best $^3/_4$-in-thick filters developed. It will be noted that filter *A* dropped below 90 per cent efficiency after accumulating a dust load of approximately 198 g per sq ft. Filter *B*, another $^3/_4$-in. filter of somewhat different design, accumulated 252 g per sq ft before the efficiency dropped below 90 per cent, which is an improvement on filter *A*, but is very poor when compared to filter *C* which is 2 in. thick. Filter *C* drops below 90 per cent efficiency only after 954 g per sq ft have been accumulated. The best $^3/_4$-in-thick filter (filter *B*) therefore has only about 25 per cent of the dust-holding capacity of filter *C* when operated under parallel conditions. All tests indicated in Fig. 2 were made with a dust concentration of 0.03 g per cu ft and an air velocity of 600 fpm through the free area.

FILTERS TESTED UNDER HIGH-VELOCITY AIR FLOW

When the use of air filters on military planes was first being considered, it was thought that a velocity of 600 fpm through the free area would be about the maximum which could be used, but in view of the much superior performance of the 2-in-thick filter over the $^3/_4$-in-thick unit, as indicated in Fig. 2, the possibility of using higher air velocities became evident.

Fig. 3 shows the comparative performance of the best $^3/_4$-in. filter with an air velocity of 600 fpm (curves *D*) and two somewhat different 2-in-thick filters at velocities of 900 fpm and 1000 fpm. Referring again to fundamental specifications that the resistance must not exceed 4-in. water gage and the efficiency must not drop below 90 per cent, it is evident from these curves that filter *D* with an air velocity of 600 fpm falls below efficiency requirements after 14 min; filter *E* with an air velocity of 900 fpm is good for 30 min; and filter *F* with an air velocity of 1000 fpm is also good for 30 min. The over-all efficiency of filter *F* is considerably better than filter *E* and it is, therefore, preferable from the standpoint of both efficiency and the space required for its installation.

From the standpoint of weight, filter *F* compares favorably with the other filters if an air velocity of 1000 fpm is employed. As an illustration, an 1800-hp engine requires approximately 2700 cfm (1.5 cfm per hp). If filter *D* is used with a velocity of 600 fpm, a net area of 4.5 sq ft will be required, and such a filter will weigh approximately 11.4 lb. If filter *E* is used with a velocity of 900 fpm, a net area of 3 sq ft will be required, and this filter will weigh approximately 12 lb. With filter *F*, employing a velocity of 1000 fpm, a net area of 2.7 sq ft will be required, and the filter will weigh approximately 11.8 lb.

TABLE 1 COMPARISON OF FILTER COSTS FOR SAME AIR VOLUME

Filter	Velocity of air flow, fpm	Filter media	List price	Per cent of cost of filter *F*	Per cent of area of filter *D*
D	600	UM-153	$26.00	87	100
E	900	UM-152	28.50	95	$66^2/_3$
F	1000	UM-155	30.00	100	60

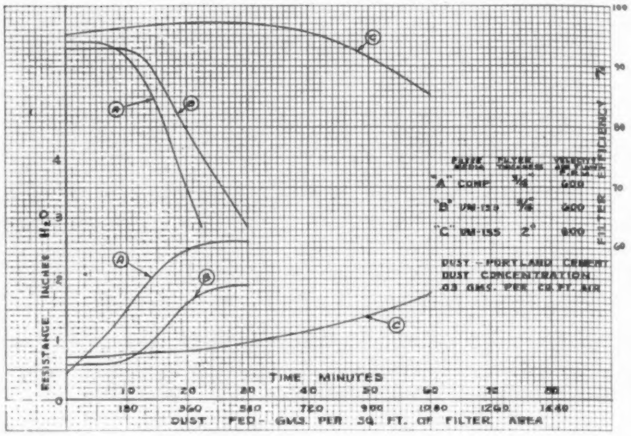

FIG. 2 PERFORMANCE CURVES OF VISCOUS IMPINGEMENT-TYPE FILTERS AT CONSTANT AIR VELOCITY

Table 1 gives a general idea of the comparative costs of the three filters for handling the same air volume at the velocities indicated.

In view of this small difference in cost and the much superior performance of filter *F*, its use in preference to the other units would seem logical, especially in view of the fact that it requires less space than either of the others.

MATERIAL AND CONSTRUCTION

Some of the original air filters made for airplane service were provided with aluminum channel frames in order to reduce weight to a minimum. It was found, however, that with the rough handling air filters frequently receive, steel channels hold up much better, especially at the corners where they are welded. The cost is less and by using 20-gage steel instead of 16- or 18-gage aluminum, it is possible to obtain a more rugged filter without increasing the weight materially.

The filter media used in all the air filters developed (with the exception of filter *A*, Fig. 2) is a combination of knit steel wire and knit copper ribbon. The knit steel wire is placed on the air-entering side, and the first few layers are crimped in order to provide space between the individual strands of media which will permit a considerable amount of dust to accumulate without blocking off a large percentage of the air passage. These crimped layers of media are followed by flat layers of knit steel wire, which forms a more dense section, and a still more dense section is formed by the woven copper ribbon. Again referring to Fig. 3, the superior performance of filter *F* over filter *E* was obtained by adding 8 more layers of crimped and flat knit steel wire. In addition to improving the efficiency and permitting higher air velocity, crowding this extra media into this 2-in. space will result in better wearing qualities. The reason for this is that these filters will be subjected to considerable vibration, and the more tightly the individual layers of media are pressed against each other, the less opportunity they will have to move and cause wear by rubbing.

INSTALLATION OF AIR FILTERS IN AIRPLANES

The size of air filter required for an airplane engine is determined by the following procedure: It is first necessary to determine the volume of air in cubic feet to be handled. The usual practice is to figure 1.5 cfm per hp at military or take-off power, whichever is the higher. The next step is to decide on the type of air filter to be employed and select a velocity of air flow for this filter which will give satisfactory performance.

The net filter area required is then determined by dividing the volume in cubic feet per minute by the velocity of air flow; and after this is calculated, the dimensions of a filter which will give this net area can be determined by the space available for mounting. As far as possible, air filters should be of rectangular shape and must be absolutely flat.

Air filters may be installed at any convenient point between the air intake and the carburetor, and this is a problem primarily for the airplane manufacturer to solve. Many installations are being made directly in the air scoops. Filters so installed should be mounted in such a manner that loose dirt particles will tend to fall away from the filter panel, and suitable means such as slots or tubes should be provided to carry overboard any dust that collects in the duct on the upstream side of the filter. The size and number of such slots, however, should be held to a minimum to avoid excess loss in ram.

On installations in which turbosuperchargers are used, the filter may be installed either before or after the supercharger.

No means need be provided for by-passing air around the filter, if the hot-air intake connects directly to the carburetor without going through the filter, but it is important that no heated air should be passed through the filter. The filter should be accessible for servicing with the removal of a minimum amount of cowling. Rapid-acting fasteners should be used to hold filter channels in place, except when the filters are installed on the pressure side of the supercharger, in which case the use of a limited number of screws is permissible.

SUMMARY AND CONCLUSIONS

1 The various characteristics of a viscous impingement-type air filter which deserve special consideration, in the order of their importance, are as follows:

(*a*) Ability to maintain a high cleaning efficiency even after a large amount of dust has been accumulated.
(*b*) Strength of construction and ability to withstand frequent and rough handling; permanency.
(*c*) Size, i.e., space required for installing.
(*d*) Weight.
(*e*) First cost.

2 The superiority of filters 2 in. thick over filters $^3/_4$ in. thick is definitely indicated.

3 Of the 30 or more filters made and tested, filter designated as UM-155 (filter *C*, Fig. 2, and filter *F*, Fig. 3) is by far the best, and costs very little more than inferior designs. An interesting sidelight in this connection is the fact that filter *E* and filter *F* are identical in external appearance, which goes to show that one cannot tell much about an air filter just by looking at it.

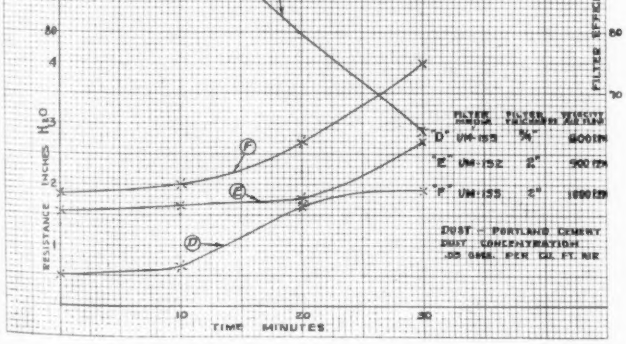

FIG. 3 COMPARATIVE PERFORMANCE OF BEST $^3/_4$-IN. FILTER AND 2-IN. FILTERS AT VARYING AIR VELOCITIES

4 It is the opinion of some authorities that a filter should be able to operate for a minimum period of 30 min with a concentration of 0.03 g of dust per cu ft of air handled, without exceeding 4 in. water gage, and without dropping below 90 per cent in cleaning efficiency. Filter *D* does not meet this requirement even with a velocity of only 600 fpm. Filter *E* barely qualifies at 900 fpm, and filter *F* barely qualifies at 1000 fpm.

5 Improved performance can be obtained from any of the filters tested by using somewhat lower velocities than those for which curves are shown in Fig. 3.

6 Test results are influenced by a number of factors other than filter design; such as (*a*) temperature, (*b*) viscosity of oil used, (*c*) specific gravity and particle size of dust, (*d*) test procedure, and (*e*) dust concentration per cu ft. These five possible variables were controlled as follows:

(*a*) All tests were made at temperatures from 60 to 80 F.
(*b*) A 120-sec (Saybolt Universal viscosimeter at 210 F) airplane-engine lubricating oil was used for charging the filters.
(*c*) Portland cement was employed as the test dust. Dust was first dried and then screened for a sufficient time to get 100 per cent through the 100-mesh screen and at least 50 per cent through the 325-mesh screen.
(*d*) Uniform procedure was followed on all tests covered by this report. For details refer to the Appendix.
(*e*) Dust concentration was maintained at 0.03 g per cu ft regardless of air velocity, by use of an automatic dust feeder of the vibration type which fed a uniform mixture of fine and coarse dust particles.

Appendix

APPARATUS AND TEST PROCEDURE

The apparatus, with which air-filter tests were conducted, consisted of a duct of sufficient length to obtain proper air distribution and mixing of the dust and air, of a size and design to take an 8 × $9^1/_8$-in. filter either $^3/_4$ or 2 in. thick. The duct was connected to a high-pressure blower and had a damper to control the amount of air which the blower pulled through the system. Inclined draft gages were used for measuring the resistance or pressure drop across the filter, and for measuring the pressure drop across the calibrated orifice, placed at the entrance of the duct to measure quantity of air flowing in the system. The test dust was introduced by a vibration-type dust feeder in such quantities that a uniform dust concentration of 0.03 g per cu ft of air was obtained. A balance was used to weigh the filter, and the dust fed into the system.

The filter to be tested was dipped in 120-sec (Saybolt Universal viscosimeter at 210 F) airplane-engine lubricating oil and allowed to drain overnight. It was then weighed and placed in the test apparatus. The proper amount of dust to give a dust concentration of 0.03 g per cu ft at the rate of air flow, employed for a period of 10 min, was weighed out. The test was then started and conducted for 10 min. The filter was then removed from the system and weighed. The dust that settled out in the duct in front of the filter was removed and weighed; this weight was subtracted from the weight of the dust fed into the system to obtain the actual amount of dust entering the filter. The efficiency of the filter was then determined by dividing the weight of the dust caught by the weight of dust actually entering the filter cell. At least three such 10-min tests were made on each filter. The test dust employed was Speed Portland cement, all of which passed through 100-mesh screen and at least 50 per cent of which passed through 325-mesh screen. Dust was dried by heating at 215 F before screening for a sufficient length of time to drive out all moisture.

ENGINEERING COURSES

Their Objectives, Organization, and Direction

By HARRY S. ROGERS

PRESIDENT, POLYTECHNIC INSTITUTE OF BROOKLYN

THE objectives of engineering courses are the perennial topic of discussion before educational and engineering societies. The annals are filled with individual views, many of which, although limited to particular fields, come under a general pattern of basic ideas. A rather extended paper of my own, presented in the *Journal of Engineering Education* in June, 1928, covers the subject much more thoroughly than I shall be able to cover it this morning. The report, of the Committee on Aims and Scope of Engineering Curricula to the Society for the Promotion of Engineering Education in 1939, is a rather thorough and searching analysis of objectives in both, to use their happy phraseology, the "scientific-technological" and the "humanistic-social" stems of the engineering curricula. Within the scientific-technological classification are included such subject-matter fields as physics, chemistry, mathematics, and engineering, and within the humanistic-social, such fields as English, literature, languages, and social studies. It is of the scientific-technological courses which I desire to speak this morning.

The aims of courses, obviously, are more restricted in their scope and more particular in their goals, while the aims of curricula must, of necessity, arising from the breadth of human knowledge, be eclectic and therefore varied in their general pattern. Some years ago it might have been necessary to sustain one's opinion concerning the objectives of the scientific-technological courses with a documentation of the opinions of others. But the studies of engineering education reported by Dr. C. R. Mann for the Carnegie Foundation and those made by the Society for the Promotion of Engineering Education under Dr. W. E. Wickenden have quite definitely established the primary aim as the teaching of fundamentals. Agreement as to such a general aim presupposes a specific definition of those fundamentals underlying the body of recorded engineering knowledge and constituting the objectives of engineering training. This assumption is not completely fulfilled.

Frequently mathematics, physics, chemistry, drawing, and such courses constituting the elements of engineering curricula are designated as fundamentals, and certain it is that they do, in their scope, embody those principles which are fundamental to all engineering. For the purpose of discussion this morning, however, let us define the term "fundamentals" as that group of general principles, physical laws, objective data, and basic assumptions which are found in the fields of physical science and mathematics, and are utilized in a specific manner for solving problems in the various fields of engineering. In my opinion there is a more or less definite procedure for effective presentation and study of these fundamentals.

ATTRIBUTES OF SUCCESS IN ENGINEERING

Before discussing the matter of objectives in engineering courses and the method of presentation of engineering subjects, however, let us again review those attributes and characteristics considered essential for success in engineering careers. Here we will eliminate the so-called broader and collateral abilities and aptitudes and direct our attention to those which specifically characterize engineers. There is more or less general agreement that they are adequately covered in classifications similar to the following:

1 Knowledge of theory, which implies a mastery of fundamental principles, knowledge of methods, a command of basic facts underlying the branches of engineering, and an ability to apply these constructively to the solution of engineering problems.

2 Knowledge of practice, which implies an accumulated body of information about the types of machines and devices available for the accomplishment of practical objectives, and concerning standards, methods, and procedures in the manufacturing and constructive arts.

3 Leadership in human efforts for accomplishing engineering projects, which implies the ability both to organize and to direct.

4 Personal efficiency manifested through habits of industry, initiative, accuracy, thoroughness, neatness, and promptitude—all those attributes so characteristic of efficient industry today.

5 Fundamental character as manifested in honest practice and ethical procedures in relations with colleagues and clients.

All of these attributes are possessed in varied measure by individual engineers and all of them are possessed in different measure by the various ranks within engineering, such as technicians, junior engineers, licensed engineers, distinguished engineers, and eminent engineers.

For the purpose of a more graphic presentation of these facts, they may be arranged schematically in a manner indicating the measure of achievement, capacity, ability, or traits, as shown in Fig. 1.

It is generally recognized, as witness the application forms for membership in our Founders Societies and the examinations given for licensure, that the competent engineer must possess all of these in a certain measure of a more or less subjective nature. This measure is more or less objectively determined, however, by the nature of experience and responsibility which applicants have discharged in the professional fields.

A pattern of attributes and achievements of any engineer may readily be drawn across these measures as a profile. One individual may, for example, excel in the knowledge of theory without possessing a collateral knowledge of practice or without exercising large responsibility in leadership. Another may be eminent because of his achievement in some field of practice even though somewhat limited in his knowledge of the advanced engineering sciences.

The college graduate will possess a specific measure of knowledge of principles and methods, but will lack, however, in his information about, or understanding of, the engineering arts. He may have had little opportunity to demonstrate leadership and yet possess great inherent capacity for it. He should have been disciplined in habits of personal efficiency. And he should

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, Dec. 1–5, 1941, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

MEASURES OF PROFESSIONAL COMPETENCY AND CONSCIOUSNESS	SUBPROFESSIONAL TECHNICIAN	JUNIOR ENGINEER	COMPETENT PRACTITIONER	DISTINGUISHED ENGINEER	EMINENT ENGINEER
KNOWLEDGE OF PRINCIPLES AND METHODS	ELEMENTARY KNOWLEDGE OF MATHEMATICS AND TECHNOLOGY	KNOWLEDGE AT COLLEGE LEVEL	BROAD KNOWLEDGE OF PRINCIPLES AND METHODS	CONTRIBUTOR TO THEORY AND TECHNOLOGY	CREATIVE CONTRIBUTIONS OF IMPORT
PRACTICAL FACILITY IN APPLICATIONS	TRAINED IN STANDARD PRACTICES	KNOWLEDGE OF AND FACILITY IN METHODS AND PRACTICES	"ACTIVE PRACTICE" IN ENGINEERING "ABILITY TO DESIGN"	LEADER IN DEVELOPMENTS OF PRACTICE	CREATIVE ORIGINALITY IN APPLICATIONS AND CONSTRUCTIVE ARTS
ABILITY TO ORGANIZE AND TO LEAD	SKILLED WORKER	SUPERVISOR OF UNIT OR FUNCTION	"RESPONSIBLE CHARGE" OF PROJECTS	ADMINISTRATOR OF LARGE ENTERPRISE	ADMINISTRATOR OF LARGEST ENTERPRISES
HABITS OF PERSONAL EFFICIENCY	INDUSTRIOUS, THOROUGH, ACCURATE, ORDERLY IN WORKMANSHIP		DISCIPLINED IN EFFICIENCY	ENERGETIC AGGRESSIVE ORIGINAL	CREATIVE IMAGINATIVE FARSIGHTED
TRAITS OF PERSONAL CONDUCT	HONEST, FAIR AND RIGHT IN CONDUCT PERSISTENT GOODSPORTSMANSHIP		PROFESSIONALLY ETHICAL IN CONDUCT	UNSELFISHLY DEVOTED TO WELFARE OF PROFESSION & PUBLIC	ALTRUISTIC INSPIRATIONAL BROAD-VISIONED LEADERSHIP

MEASURE OF COMPETENCY AND CONDUCT QUALIFYING FOR LICENSURE AND SOCIETY MEMBERSHIP.

FIG. 1 MEASURES OF PROFESSIONAL COMPETENCY AND CONSCIOUSNESS

respect and honor his profession by honest, fair, and upright conduct.

There are very obvious reasons for focusing upon the mastery of theory and drill in its constructive applications in the college classroom. The most obvious is that such mastery and resulting facility are fundamental to growth of individual power and ability. Other reasons, however, circumscribe the objectives of the classroom. It would obviously be impossible to bring the experience of the field to the college campus without great expense and artificiality. We must depend, therefore, upon qualifying experience after graduation for the attainment of that professional competency which demands a knowledge of the arts. In the classroom and in the laboratory, however, we can bring together the conditions and the facilities through which the embryo engineer may grow most rapidly in his knowledge of fundamentals and be disciplined most effectively in habits of personal efficiency.

BODY OF ENGINEERING KNOWLEDGE

The evolution of engineering thought, as we know it today, and of engineering practice, based upon that thought, has given us a body of knowledge based upon facts and principles that we may place in the following five broad classifications:

1 Generic principles including such basic concepts as the laws of statics, the law of conservation of energy, the principles of thermodynamics, the laws of electromagnetism, and so forth.

2 Certain hypotheses such as plane sections before bending remain plane after bending, that certain simple structures are statically determinant, and many other analogies which have been accepted in the technology of various fields.

3 Empiricisms such as the properties of materials which have been observed and measured in the laboratory and which are recorded abundantly in handbooks.

4 Derived principles which have been developed in various fields of practice for the purpose of facilitating the application of generic principles, of accepted hypotheses, and of measured empiricisms to the solution of more or less standard problems.

5 Specifications and standards which have been developed through the extensive field, shop, and office practices of engineering groups.

These principles, hypotheses, empiricisms, standards, and practices are the foundations of engineering thought and the working tools of the engineer.

A sound program of objectives for engineering training must include a critical mastery of the fundamentals together with the development of certain facility in their application. These two associated elements, first, critical understanding, and second, a power of constructive application, are complementary. One may not possess either in any considerable degree without some measure of the other.

Since engineering theory is founded upon generic principles, hypotheses, and empiricisms, the logical approach to a comprehensive understanding of it is through a mastery of these fundamental principles. These are traditionally presented in such basic courses as mechanics, electrical circuits, thermodynamics, engineering materials, and the like.

On the other hand, derived principles, which have evolved in the development of technology, and specifications and standards, which have developed, in large part, as the product of engineering arts in field and shop, have generally been presented in such applied courses as electrical machinery, steam power, and structural design. While in basic courses the emphasis has been upon critical understanding, in applied courses the major emphasis has traditionally been upon facility in use.

FOUR STAGES OF DEVELOPMENT

In the progress toward the mastery of knowledge and the development of the power of constructive engineering thought, at least four separate and distinct stages may be discerned:

1 A recognition of the abstract generalized principle within the boundaries of a specific problem.

2 The association of this principle with others as a working

tool for the solution of a variety of problems presenting different external appearances.

3 The development of a critical understanding of the abstract principle in association with the methods of its application.

4 Facility in its constructive application to the solution of new problems.

The first of these is in large measure the responsibility of the instructor in the presentation of each of these general-purpose tools. The second quite naturally grows out of the use of the principle in the solution of a variety of problems and becomes therefore the responsibility of the student. The third will result from a critical examination of a large number of problems for the purpose of identifying and generalizing the concepts used in their solutions; this may be done most expeditiously under the guidance of the instructor. The fourth, like the second, implies the cultivation of the facility in the utilization of principles for the solution of new problems. It grows out of the drill and experience of the student.

The principles around which basic courses are organized are of a rational and generic nature such as the laws of equilibrium and the law of conservation of energy; or they are of a hypothetical nature such as the stress and strain relationship in a beam under flexure. In the development of critical understanding of them the most important factor is a recognition of the physical concepts upon which they are rationally based. Here is the particular in which most crimes of omission in teaching are committed and here physical meanings are too frequently covered up by mathematical symbolism. The physical concepts are frequently so obscure in the presentations of textbooks that students in their study of them do little more than verify the algebraic method of derivation. This may be true, for example, in such subjects as internal shear in beams and flow through a submerged weir. Textbooks are generally written for the logical presentation of concepts in rigorous mathematical terms and it is this which adds to the obscurity of physical relationships.

The free-body sketch and graphical methods are universally used in presenting physical concepts underlying abstract analyses. We can go still further with such methods. We may also use laboratory demonstration to advantage. There is a great opportunity to improve much of our teaching by the more universal use of sketches, models, and diagrams for the presentation of these abstract physical meanings which are the foundations of engineering thought.

Empirical principles are, on the other hand, best studied in the laboratory. Most of them are very definitely limited in their applications and it is most important that students understand their origins and limitations. We will improve our teaching and conserve our time as we pay more attention to these vital factors.

In contradistinction to the outline of a basic course around an organization of principles, the outlines of applied courses are usually made around types of machinery or structures as, for example, the outlines of courses in structures, gas engines, or electrical machinery. The major purpose of applied courses is the development of a critical understanding of derived principles and of facility in their application to the design of machines or structures or for the explanation of their performance. In a study of derived principles, it is essential that we give constant and unremitting attention and emphasis to the origin and limitations of working data and formulas. I have personally seen the roof of an industrial building fail under a snow load because some designer had utilized an empirical column formula for the design of a strut which had a ratio of length to least dimension far beyond the limitations of that formula as determined by the data from which it was derived.

Facility in constructive use is based upon intensive drill in methods but should not be developed at the expense of the recognition of the underlying principles and of the processes through which the adapted tools have been derived. Students are prone to follow method without critical understanding of the underlying principles. Instructors are prone to emphasize method at the expense of principles.

In the long run, however, facility in the use of principles, either generic or derived, to the solution of new problems is based upon a critical understanding and a conscious recognition of the engineering thought processes. No other one thing ties the engineering profession so closely together as this way of thinking.

The need to understand the physical meanings underlying principles and hypotheses and to know the origins and limitations of empiricisms and of derived rules gives us the most vital suggestions regarding the organization and presentation of engineering courses. The practices or arts in civil, electrical, or mechanical engineering are widely differentiated but the method of problem solving is common to all engineering fields.

In addition to this common characteristic in the way of thinking, certain other attitudes and aptitudes are characteristic of all engineers, such as a practical philosophy regarding engineering work, disciplined habits of work, and an ethical attitude toward colleagues and clients. These are, likewise, attributes which should be developed in college and which are tested and appraised in the licensure of engineers and in their admission to professional societies.

Because engineering is directed toward the improvement of comforts, the relief of labor, and the extension of the environment of mankind, and all of these embody the use of energy, materials, and capital, it is dominated by a practical philosophy of efficiency in the use of energy, conservation in the use of materials, and economy in the expenditure of money. All of these purposes should be woven into the pattern of engineering courses.

This emphasis upon efficiency, conservation, and economy finds its counterpart in the demand for personal efficiency by the profession and in a college training emphasizing accuracy, industry, thoroughness, neatness, promptitude, and the like.

With a growing sense of professional consciousness and an emphasis upon ethical conduct, a movement is now evolving to interest faculties and students in the study of professional ethics.

The building of engineering curricula and the co-ordination of courses into sequences should be determined by an effective progress toward the mastery of fundamentals and facility in their constructive application to various practical fields. The attitudes and points of view expressed in practical engineering philosophy, personal habits, and ethical conduct find their place in all courses regardless of the particular emphasis in scientific thought or technology. The integration of all these elements in a program of training requires a closer study of course objectives and of engineering curricula than is usually made. Courses have been too frequently assembled rather than co-ordinated. Some institutions are, however, making substantial progress in unifying their objectives and in integrating their programs.

The pressure of the need for broader training requires a continual restudy and appraisal of engineering courses and objectives for the purpose of securing more satisfactory results in less time. It is my own conviction that this can be done when teachers and engineers alike better understand the engineering way of thinking and when the student is led to comprehend the thought process along with his pursuit of mastery of, and of power constructively to use, engineering principles and methods.

INDUSTRIAL MARKETING

Third Annual Meeting of the A.S.M.E. Management Division's Committee on Industrial Marketing

[In connection with the Annual Meeting of The American Society of Mechanical Engineers, New York, N. Y., Dec. 1–5, 1941, the Industrial Marketing Committee of the Management Division held its third annual meeting. The program comprised three papers—the opening remarks of the chairman, an address, "Industry's Search for Industrial Markets," by Elmo Roper, and "Industrial Marketing and the National Defense," by Tell Berna. Professor Bangs' remarks and a report of Mr. Roper's address, with the discussion it provoked, are presented in what immediately follows.

Mr. Berna's paper is also published in this issue, pages 213 and 214.—EDITOR.]

Industrial Marketing in a Defense Economy

By JOHN R. BANGS

CHAIRMAN, A.S.M.E. MANAGEMENT DIVISION

AT THE 1939 meeting of the Marketing Committee of the A.S.M.E. Management Division, Frederick B. Heitkamp's paper,[1] "Gearing Engineering to Sales" and R. L. Gibson's paper,[1] "Market Research in Introducing New Industrial Products," initiated a movement in mechanical engineering that many of those present believed might lead to a movement in the field of marketing comparable to the work of Frederick W. Taylor in production.

Last year, Willard Chevalier and Robert Thurston Kent carried the movement forward with two striking presentations. Colonel Chevalier spoke on "Industrial Marketing and Industrial Advertising" and left with all of us this fundamental concept: Every manufacturer of a product must manufacture two things—he must manufacture the product to be sold; he must also manufacture the order to sell that product.

Mr. Kent's excellent paper[2] on "Marketing Analysis From Management Standpoint" made a deep impression on all who heard him. His plea for continuing market analysis struck a particularly sympathetic note and the idea brought forth that the sales organization is a two-way channel stimulated much thought and discussion.

SELLING IN A WORLD AT WAR

Much has happened since last we met. We are now, to use Major Nichol's phrase, "Selling in a world at war." Today, each and every one of us must make sacrifices if our way of life is to continue. But when defense efforts come to an end and easy orders no longer flow to our factories, business should not fold up overnight—not if businessmen look ahead and make ready.

Little was done to cushion the shock for readjustment that followed the last war. At that time people believed the economic cycle would gradually adjust itself to peacetime conditions. They thought that little if anything could be done to speed or smooth the change-over. The depression that followed was a bitter lesson.

Today, our thinking is different. Everything possible will be done to prevent a recurrence of 1929 to 1932. It will not be easy. Smoothing the transition from all-out defense to peacetime production presents a big challenge to human ingenuity and resourcefulness.

In other words, we must, to paraphrase Mr. Kettering, "find out what we are going to do when we can no longer do what we are doing now." Dr. Karl Compton, president of the Massachusetts Institute of Technology, recently completed a survey showing that 1008 of our leading business organizations will spend in 1941 a total of 117 million dollars for technical research. This ranges from two tenths of one per cent of gross sales in the leather industry to three per cent in the machinery industry.

RESEARCH NOT LIMITED TO TECHNICAL ACTIVITIES

But research is not limited to technical activities. Maj. F. W. Nichol, vice-president and general manager of the International Business Machines Corporation, in a recent address before the Sales Managers' Bureau of the St. Louis Chamber of Commerce, said, "..... every good sales executive has dreamed of the day when he could use his sales force to do a lot of things which he has never been able to find time for them to do, such as:

(1) Strengthening and solidifying accounts; (2) teaching customers how to get full benefits from his company's product; (3) extending the use of his product with present customers; and (4) doing sheer missionary and educational work, and a host of other things. That time," he continued, "has now arrived for some businesses."

I heard on good authority recently that one large firm will spend one million dollars on market research in 1942. A poll taken of some 40 operating executives of the leading companies in 40 major industries showed that one third of the companies represented will increase their advertising appropriations substantially for 1942, and one third will maintain larger sales forces. Almost without exception, the remaining two thirds

[1] "Industrial Marketing," MECHANICAL ENGINEERING, March, 1940, pp. 215–218.

[2] See MECHANICAL ENGINEERING, November, 1940, pp. 791–792, 799.

will spend at least as much money on advertising as they did this year, and will maintain at least their present sales forces. No function of business today faces a greater challenge than marketing. We must not let marketing become a lost activity. And those who do will find their cups of business activity empty indeed when boom defense orders dry up.

Industry's Search for Industrial Markets

REPORTED BY E. H. HEMPEL

RESEARCH SECRETARY, A.S.M.E. MANAGEMENT DIVISION

ELMO Roper, author and analyst of public opinion, who has done extensive private consultant work, as well as surveys for *Fortune Magazine* and *Defense*, mentioned that fundamentally two questions cause management to undertake market research: (1) What is going to happen? and (2) Why does the public not buy our product? There is a definite need for having answers to these questions, and market research and public-opinion research are undertaking to provide them.

The change from seller's to buyer's markets, which has been effected in many industries, and the fact that in many corporations management has lost direct contact with the public intensify the need for market research, and for these reasons a definite technique is needed to find out directly from the public what it wants.

"Sampling" the opinion of the public is the main method of the required technique, and in order to sample properly three main points must be kept in mind:

1 The people considered in any sample should represent "the universe to be measured in microcosm."

2 The questions should be phrased most carefully.

3 The field work (mail inquiries, personal interviews) should consider the characteristics of the product and of its buyers.

As quite a few different methods can be chosen in reference to each point, only a careful selection and combination of the best suited methods will give useful results.

In order to obtain a sample which would represent America in microcosm, attention to the following factors in forming the sample was recommended: (1) geographical considerations, (2) occupational considerations, (3) sex, (4) age, (5) economic level of person, and (6) size of place.

In order to formulate the questions in a most satisfactory manner, Mr. Roper recommended special attention to psychological aspects and to the selection of words. He cautioned against the use of "loaded" words or phrases, and declared that the field of "semantics" (proper selection of words) is still an uncharted sea, in need of further exploration.

In reference to the methods of collecting information, personal interviews were recommended as by far the best, if at all possible, in spite of their costliness and the difficulties of developing good interviewers, methods of interviewing, and the like.

The main difficulties still to be explored and solved lie in:

(1) Finding better methods for qualitative appraisal of the answers received, and in (2) improving the science of semantics (selection of words and phrases).

Through various samples was brought out the fact that the determination of "trends of opinion" is perhaps the most important part in diagnosing conditions.

In summing up his experiences gained in "eight years of asking questions," Mr. Roper stated the following:

1 The native common sense of the common man should not be underestimated. If given full facts he is bound to decide correctly and like a fair impartial jury.

2 The rewards of industry, until now not properly distributed, should be redistributed more adequately. Taxation, now imposed to bring this about, is hardly the best solution.

3 The gap between top management and the public should be bridged better by more market and public-opinion research.

4 The areas of ignorance, where the public is still backward, or is not sufficiently educated, should be uncovered and steps should be taken to correct the situation.

5 The channels between the common man and his leaders should be cleared, so that actions (private or public) could be in line with the real wishes of the people, and dictation or similar influences by militant pressure groups could be avoided.

By giving the people an opportunity to be articulate and by creating proper means to that end, a definite step is taken to make democracy survive any totalitarian system.

DISCUSSION

Prof. Harry J. Loberg, Cornell University, reiterated the importance of samples, questionnaires, and field work, and recommended adoption of the six factors to be considered in forming a satisfactory sample. He agreed with the importance given to semantics, and stressed the fact that the importance given to the questions by the readers is another point to be observed and studied. In reference to geographical considerations he refined the concept to plant, community, and district opinion, which would have to be ascertained.

He warned, however, against the difficulties in bringing about a more equitable distribution of the rewards of industry. How should it be worked out? Government interference? How should a value be fixed for every man? Obviously there would be differences in evaluation if done by different men. Equally doubtful was he about the uncovering of the areas of ignorance. How does one know whether the results of a poll are due to ignorance of the people or to manipulations by the pollers? Would even good polling make us all followers of the public opinion so ascertained?

In general, however, he recognized the similarity of public-opinion research and marketing research.

Roland G. E. Ullman, marketing counselor, Philadelphia, gave a number of examples and cases in which he had made public-opinion studies, both dealing with strike situations.

In both instances, valuable facts were discovered by these studies which make it possible to correct certain underlying conditions (housing policies, wage policies, payment practices, company stores, and the like).

Mr. Roper, in his final summary, conceded that neither public-opinion research nor marketing research is as yet a perfect science, and that still quite some improvements will have to be worked out, but he upheld his point that in marketing a democracy the real and true public opinion ought to be brought into the open, even if the right method of doing it might still have to be devised.

INDUSTRIAL MARKETING *and* *the* NATIONAL DEFENSE

By TELL BERNA

GENERAL MANAGER, THE NATIONAL MACHINE TOOL BUILDERS ASSOCIATION, CLEVELAND, OHIO

THE gentle art of persuasion is not new. It is as old as the human race. We have always been under the necessity of "selling" something to somebody. It has long been associated with lying, deceit, and fraud. For centuries the first rule of commerce was "caveat emptor," let the buyer beware. It is only in the last century that wiser men have adopted a policy of candor and truthfulness in selling as a foundation for a more substantial and enduring type of business.

It is in fields where a relatively limited group of possible buyers is available, and in which sales must be made over and over again to the same customer, that the imperative necessity for honorable dealing is obvious. There is still the temptation for those who sell consumer goods to rely on the adage that "there's one born every minute," but in the field of industrial sales, such a policy is suicide. From every motive of self-interest, those of us who feel that industrial selling is important today are not speaking in defense of improper sales methods, exaggeration, or misrepresentation of any kind. In this field sales efforts must be based on accurate information. Therefore, our salesmen must be thoroughly trained.

FUNDAMENTALS OF INDUSTRIAL-EQUIPMENT SELLING

The sale of industrial equipment begins with a thorough understanding of the product we have to sell. That is fundamental. Yet any purchasing agent can tell you that many of the men who call on him today do not have that thorough understanding. It is the business of the sales manager to see that his men know their product and know it well.

Machine-tool builders very often show their awareness of the need of having thoroughly well-informed salesmen by recruiting the sales force from the ranks of their demonstrators. These men understand their machines and know just what they can do on a wide range of work. But I am afraid we do not continue to train these men. We do not realize how soon they forget. The product they helped to build and which they understand fully is changed, discarded, and replaced by new and different ones as the years slip by.

We must recognize, as the Army does, the need of refresher courses, of retraining, and of retraining all ranks, from the top down. The Army War College and the Army Industrial College, for instance, are for officers of mature years and relatively high rank. These "colleges" demand hard work, and provide courses of considerable difficulty. I doubt if very many heads of industrial companies urge their sales executives to find ways of broadening their understanding and studying new tactics. Usually, a sales manager who joins an association or seeks opportunities to discuss selling methods with other sales managers does so entirely on his own initiative.

We assume that we will have to redesign our product from time to time. We realize that better methods of manufacture and of control of operations must be introduced into our shops. We should be conscious of the same need for new ideas and new methods in the sales department. We get ideas on improved products from our customers. We get ideas on better shop management from a multitude of sources—magazines, books, conferences, visiting salesmen. Our sales department should also be in constant touch with outside sources to develop new techniques of selling. These ideas should be passed on to the salesman in the field.

There is need for thought on the more effective presentation of what the salesman has to say. There has long been a feeling in industrial sales departments that "canned" sales talks are of no value in this field. The salesmen consider it beneath their dignity and an affront to their customers to memorize a presentation. There may be some point to this, but it does not follow that we need give no thought to what we can do to tell our story most effectively. Every call by every salesman represents a substantial expense, justified only if it leads toward a future order large enough to warrant the cost. Too often a salesman opens a customer's door without having a definite idea of what he is going to say. Now between a "canned" talk and no plan at all, there is a tremendous difference. I suggest that every salesman have a definite objective on every call.

Since he must describe a certain machine over and over, he should have developed the most effective way to do it. He should have exactly the photographs or samples he will need. There should be no glib "patter," but there must be sincerity and accuracy, and there need be no groping or floundering.

There are certain stereotyped objections that the salesman knows from long experience are bound to come up again and again. There is no excuse for not having thought out the most effective way, or several effective ways, to meet every one of them, without argument or a contentious attitude. These are matters for frank discussion between the sales manager and his men at frequent intervals.

Having developed the material we must go further and insure that it is effectively presented. Few salesmen have taken enough interest in their work to take a course in public speaking. It is not what the salesman knows but what he is able to impart that influences the sale.

Unfortunately it is difficult for a sales manager to find out how effective a salesman really is. Within limits, the record of sales made and lost tells the story. But if these figures are not satisfactory, what then? If the sales manager calls with the salesman, the customer tends to direct his conversation to the sales manager. The salesman defers to his superior. Usually the sales manager does most of the talking. To call on the customer without the salesman weakens the salesman's standing. The best suggestion seems to be for the sales manager to make a deliberate and persistent effort to pass the ball to the salesman during the visit to the customer.

INDUSTRIAL SALESMEN OF THE FUTURE

The kind of salesmen we must have cannot be hastily found or hastily trained. Therefore, the manufacturer of industrial equipment should now be giving thought to his sales department and its fitness to meet conditions we may face after the emergency.

Contributed by the Management Division and presented at the Annual Meeting, New York, N. Y., December 1–5, 1941, of The American Society of Mechanical Engineers.

To sum up, we need a sales force that is well-informed, accurate, alert, and flexible. Things are moving fast, and they aren't going back to some old and well-known situation, but to new ones. These new situations cannot be dealt with as they arise, they must be anticipated. There has been a definite trend in the sale of industrial equipment. Beyond the fundamental need of a thorough understanding of the product he is trying to sell and skill in presenting what he has to say, the salesman must now offer an additional type of knowledge. He must understand the customer's problems. He must understand clearly what his product will do for the customer. We are witnessing a definite trend toward a type of selling that may be accurately termed production engineering.

In this type of selling, the salesman studies and analyzes the present methods of the customer and presents a report of what new equipment will do. In other words he translates what he has to sell into terms of increased accuracy, or better finish, or increased output per man-hour. He can still tell you in detail how his machine is built, but he can also speak in terms of return on investment. He realizes that no one buys a machine because he wants antifriction bearings and automatic lubrication and rapid traverse. He buys these things because they offer him increased profit. It is production that we have to sell; it is increased profits that we must offer our customer.

If you asked some of our friends in Washington to speak on this subject, they would say: "There is no place for industrial marketing in a defense program." Why have salesmen in a seller's market? Colonel Chevalier used an apt phrase in his talk at these meetings last year when he said, "We are, at the moment, pumping into a vacuum."

There seems to be in the minds of these government officials a deep-rooted objection to salesmen, to dealers, and to selling in general. They feel that it is the business of a salesman by glib talk, by fraud and indirection, to persuade someone to buy something he doesn't need at a price that is higher than he should pay. Perhaps there are such salesmen still. But they are few and will be fewer. They are the exceptions. These officials feel much the same way about advertising. They do not understand why, under present circumstances, selling and advertising expense are necessary or even desirable. Why not eliminate them and so reduce the price?

It is true that most manufacturers of industrial equipment at the moment do not need salesmen to get orders. But they do need salesmen to give the customer complete and accurate information without the delay involved in getting it from the factory, and they do need salesmen more than ever before to keep the factory informed, to straighten out orders, to get the priority certificate, the formal order, that last essential bit of information without which the order is incomplete. Our plants are handling an unprecedented volume of work. They must plan production far ahead. It doesn't do any good to finish a turret lathe if they haven't even received instructions on the tooling required.

If this volume of work is to be handled without confusion, the sales department must get complete information into the hands of the factory as soon as possible. One week saved in starting the process of manufacture is just as valuable as one week saved on the assembly floor.

PRIORITIES AND GOVERNMENT CONTRACTS

The operations of priorities and the handling of government contracts are new and strange to many of our customers. The sales engineer who is willing to study these problems may be of substantial help to his customer. Above all, he can explain his own company's inability to furnish what is needed, or the necessity of shoving a delivery back several months, due to the operations of the priority system, in such a way as to remove any resentment that might linger to spoil his business contacts after this emergency is over. Nobody is more painfully aware that this is a seller's market than the buyer. He is consequently very sensitive to any attempt on the part of the seller to take advantage of it. We need as never before to develop a close and friendly understanding for the sake of our future business. It will not always be a seller's market.

It is for this reason that a carefully prepared campaign of industrial advertising is an essential element in any sales program today. Advertising must be a continuous process, not an intermittent one. It must be done in good times as well as bad.

It is difficult to appraise good will accurately in terms of dollars, but it is an asset of great value in the field of manufacturing industrial equipment, and we need to carry over into the postemergency period every asset we can muster.

Now as never before, the sales engineers in the machine-tool industry are production engineers. They have made a substantial contribution to the defense program. In countless defense plants, they have suggested methods and equipment that will produce the parts needed to the limits required in the quickest way. As the program develops I hope we can still further refine the methods used so as to reduce the costs of the munitions we must have and to relieve the demand for trained men by increasing the output per man-hour.

FUNCTIONS OF DEALERS AND SALESMEN

In order to make the picture complete, I should mention the role of the dealer in our field. To many companies he is the sales department. He does the things I have been discussing. In many cases he finances the transactions as well. It is to the dealer that many manufacturers look for prompt payment after industrial equipment is shipped. The red tape and delay involved in securing payment on government contracts are often handled by a dealer, and the manufacturer is spared at least that annoying detail.

Normally, a salesman has two major functions: First, to bring information on his company's product to the buyer in convenient form and persuade him to buy it; and second, to keep his own company fully informed on market conditions and the needs of his customer.

We must not overlook the fact that all manufacturers of industrial equipment are not busy. There are still companies that need more business. Their salesmen and their dealers still have that first function to perform. But for every manufacturer of industrial equipment, the salesman must be a source of accurate information on his customers' needs. If new features are needed on the equipment being sold, he is the first to hear of it. If the equipment he sells is not satisfactory, he is called in by the customer. The factory should be informed on the performance of the equipment after it is installed so as to check the production estimates that were made. We have a right to demand painstaking accuracy in his reports, but the salesman also has a right. He has a right to be heard patiently and courteously even though he is reporting serious trouble. We must avoid giving him the impression that he is only expected to bring us good news. What we really need is facts. This function of the salesman should be of very great value and is often neglected.

Performance data now collected, and procedures developed during the emergency will be of critical importance when the emergency is over. Our engineers are thinking about the redesign that must come—the new products that can be offered, and some of them have gone far beyond thinking. Management is doing its best to build the financial reserve that must carry the company through the next depression. The sales department must also build a reserve; a reserve of new methods and trained men.

FREE ENTERPRISE
and WORLD POLITICS

By WALTER WHITE

BUSINESS ADVISORY COUNCIL FOR THE U. S. DEPARTMENT OF COMMERCE

CAPITALISM and the profit motive are inseparably entwined with the institution of free private enterprise. Collectivism in any form, whether by state ownership or by state domination and regulation of daily business transactions, is the antithesis of free enterprise.

You are all certainly aware of the political developments of recent years, as a result of which the areas where free enterprise continues to exist have progressively shrunken. Under the necessities of a war economy, it is essential that centralized authority replace the decisions of the individual managers of business, but even before the war the institution of free enterprise existed among the axis powers in form only under a fascist domination, while in Russia it had ceased to exist at all.

PREWAR TRENDS TOWARD SOCIALIZATION

In the Scandinavian countries and to some extent in Great Britain, free enterprise has for years been subjected to a gradual socialization, the counterpart of which in this country, under an accelerated program during the last eight years, is deemed by some business and professional men to be nothing less than rampant radicalism.

We have witnessed here a consistent and accelerated encroachment of the state on the freedom of private enterprise. Tax laws, labor laws, antitrust policies, agricultural policies and laws, security and banking laws, as well as a host of other regulatory measures, limit liberty of action and reduce individual initiative springing from the profit motive.

There is today in the minds of most of our citizens a conviction that, unless the free-enterprise system satisfies the basic social needs of the individual and of the community, then the government must do the job.

PRESSURE GROUPS AT WORK

Already several particular groups feel that their immediate self-interest lies in reliance on State responsibility for social betterment and economic security. This is the natural result of a system which has brought perhaps disproportionate rewards to a few and has failed to solve the problem of unemployment. It seems to make no difference that the same system has produced a much higher standard of living for our people as a whole. The average wage of a worker in any of our mass-production industries will buy far more of the necessities or luxuries of life than the wage of a similar worker in any other country in the world, and still the demagogue can find strong political support for measures which lead to state socialism.

We will all admit that the system of free enterprise operating on the profit motive has its shortcomings and is subject to abuses.

You know what those abuses are. In great measure they were responsible for the depression of the early thirties and the wave of social legislation which followed. And yet it is my firm conviction that no other system offers to mankind a better stimulus for advancement, a greater spur to individual initiative, or a broader opportunity for self-expression. There must be reward for achievement. Ideally, you may say that spiritual rewards should be an adequate incentive. In principle, I agree. There is a crying need throughout the world for a regeneration of spiritual values. But man is still primitive enough to seek material and physical things in return for his labors. The bare necessities of life, food, clothing, and shelter come first, but beyond that in a competitive society, we all strive for that higher standard of living which is the reward for success.

OUR POLITICAL AND ECONOMIC STRUCTURE THREATENED

I am one who believes that the compromise between socialism and free private enterprise can continue for a long period in this country provided that businessmen act with wisdom and provided that the present world conflict brings about no cataclysmic changes in our political and economic structure. It is this second proviso which carries the greatest threat. Sincere and patriotic citizens have questioned the wisdom of our involvement in this conflict, because they honestly believe that whatever the military outcome, we will lose the institution of free enterprise and become a nation of individuals economically dependent upon political organisms. They believe that the necessary participation of the state in the defense-production effort and the consequently enormous public debt will make it impossible for government control to withdraw at the end of hostilities and allow private enterprise to resume its normal function. It may very well be true that an isolationist policy would call for fewer sacrifices during the lifetime of those who are beyond 40 years of age today, but I am quite certain that if we permit an axis victory in this war, we will be piling up for our children a far worse situation than we face today. Beyond that, I consider the question of our involvement in this war to be an academic one. We are part of it now; the uncertainty lies only in how long it will last, how many lives it will take, and what it will do to our social-political structures.

And so, as a result of world politics of a revolutionary character, superimposed on a natural evolutionary movement, free enterprise as the mainspring of social and economic progress hangs in the balance.

A CHALLENGE AND AN OPPORTUNITY

Lest you think of me only as a dreadful apostle of gloom, let me say that I regard the situation as a challenge and an opportunity rather than as an inexorable fate. You as engineers know that to solve a problem you must be in possession of all the facts and then face them fearlessly. An attitude of defeatism is not going to save capitalism, private enterprise, and the incentive system. American business has no peer in selling its products and its services to the public. That art has been perfected to a high degree, but business has failed miserably in the essential task of convincing the public that it can produce and

Address presented at the Fall Meeting, Louisville, Ky., October 12–15, 1941, of The American Society of Mechanical Engineers.

distribute needed goods far better under private than under public management.

Under the defense program private industry is meeting a severe test. Will management have the wisdom to put aside temporary advantages in favor of its future existence? Personally, I think it will if business leaders read the public mind correctly and are ready to make the necessary sacrifices and adjustments. But this will not be enough. When the military phases of the war are over, an even severer test will come. How will we then keep men employed and sustain purchasing power in converting military production to civilian needs? The wisdom and the genius of engineers, research scientists, and economists are needed not only to plan ahead for that inevitable day but to put those plans into effect. Business management must prepare itself to meet this test for, if it does not, then public agencies will take over those functions of production and distribution necessary to provide our citizens with jobs and with goods.

ADJUSTMENTS REQUIRED IN PRIVATE-ENTERPRISE SYSTEM

It may be useful to give some attention to the kind of adjustments which the private-enterprise system is likely to have to make in order to survive the present situation. Much has been heard in recent years of the evils of large corporate enterprises—their analogy to a fascist régime under private control, their power over the economic destiny of many people, and their monopolistic tendencies. Various remedies have been proposed; some have been tried out. Many reformers believe that size itself is evil, that all large companies should be broken up, or small enterprises encouraged by public subsidies. Others would subject all large concerns to regulation similar to that adopted for the public utilities. Still others advocate public ownership or at least public yardstick competition. And then there are those who seek to impose changing administrative, economic, and social philosophy through constant harassment under the vague standards of the antitrust laws.

All of these methods appeal to some political segment of the electorate seeking special advantagef or itself. However much human and political appeal may rest in the corner grocery store as the symbol of a small individually owned business, we must remember that mass production and mass distribution have made industrial America. It is the engineering and research work of large concerns, coupled with the vision and financial resources of management, which have made us industrial nation number one and have given us the highest standard of living in the world. More important still, it is our mass production, our engineering, and our research which offer to oppressed peoples of the world the only hope of victory over the axis powers.

To do anything drastic which would impair the smooth functioning of our industrial machine would be a most foolhardy national policy at this particular time.

Profits will be sharply limited. Nationally advertised and branded merchandise will have tough going. Prices will be fixed. Management will be told what it can make and how much of each article. Organized labor's influence will continue to grow with respect to both government and business policies.

Looking to the postwar period, I believe that investors and management must both adjust themselves to some very different standards. Former concepts of a reasonable return on private capital will have to be modified. Savings, looking for a 10 per cent return in productive enterprise, even of a speculative character, are likely to lie idle. More drastic excess-profits-tax legislation, which may be expected within the next year, will probably remain on the statute books with only slight modification after the war is over.

All companies will be required to conform to new standards of social responsibility involving wage rates, conditions of employment, maintenance of quality, advertising practices, treatment of customers and competitors, rights of stockholders, and acceptance of community obligations.

Social security embracing almost all of our citizens and protecting individuals against most of the common hazards, under a national administration, will be the order of the day.

If the reforms which can be foreseen are not carried too far, if our business statesmanship can adjust itself to the new order without cracking, and if our political leadership really wants to preserve a modified private-enterprise system, then we may look forward with hope to very much better days. Those who have at heart the real interest of the American people will not judge the spiritual or economic welfare of the nation by the number of millionaires in the country. But by the same token our progress will cease if reasonable rewards are denied those who have the genius, the ability, the initiative, and the will to invent, to lead others, and to use their talents to better advantage than the next man.

HOW TO SAVE THE FREE-ENTERPRISE SYSTEM

You may ask me: What can those who have an interest in the free-enterprise system do about its preservation?

First of all, you can preach among your associates and clients the need for adjustment to the trend of the times, and the wisdom of a realistic answer to this pressure from the masses for social and economic improvement and for more equal opportunities to enjoy the better things of life. Professional and business men must be the first to admit weaknesses in our system where weaknesses exist and must show a willingness to face needed changes.

Your second opportunity to help preserve private enterprise is in the field of politics. Politicians, with few exceptions, are responsive to what they believe their constituents want, regardless of their personal convictions. Effective pressure groups are thoroughly organized for political action by congressional districts. This is true of the most successful lobbies in Washington, namely, the farm group, the war veterans, and the labor organizations. The advocates of the private-enterprise system either do not think that its defense is necessary or they lack the initiative to organize for political action.

In the past, most business people and, I suspect, a majority of engineers, also, have limited their political activity and interest to the support of a reactionary candidate in the national elections. Without wishing to be critical, I must say that businessmen and engineers are generally inept at political procedures.

A FERTILE FIELD FOR POLITICAL ENGINEERING

And so my final suggestion to you as individuals and as an organization is that you devote some of your time and talents to political engineering. Get to know your congressmen and your senators personally. Find out what their problems are so that when you discuss your own views you will know how best to answer the arguments of other constituents.

The democracy under which we live today is of course distorted by the military necessities of the moment, but it still looks pretty good to us alongside of other forms of government which are challenging our cherished institutions. The kind of democracy you and I believe in has its internal weakness and its internal enemies as well. If it does not provide something more than the economic necessities of life for the masses, then it will be dragged by the electorate into state socialism. But if those fundamental needs can be met and private enterprise is strengthened by appropriate profit incentives, then there are endless new frontiers awaiting the ingenuity and daring of free individuals.

The EDUCATIONAL *and* TRAINING PROGRAM *at* G.E.

By A. R. STEVENSON, JR.,[1] M. M. BORING,[2] and T. C. JOHNSON[3]

ALMOST everyone has had occasion to look back upon his school days and wonder what has become of the knowledge he was supposed to have amassed during his years of schooling . . . one trouble is that the subject matter in question was learned in isolation . . . it was segregated when it was acquired and hence is so disconnected from the rest of experience that it is not available under the actual conditions of life. . . . We often see persons who have had little schooling. . . . They have at least retained their native common sense and power of judgment, and its exercise in the actual conditions of living has given them the precious gift of ability to learn from the experiences they have."[4]

The words are those of a famous educator who was speaking about education in general; they have no particular reference to engineering education. However, this quotation does serve as a text for a discussion of the advantages of mixing education with experience in the postcollege period.

The age-old idea of apprenticeship must be revivified in order to form a better connection between what is learned in school and its application in real life.

Industry should not attempt to compete with the colleges in teaching the educational fundamentals. Any attempt to do this would be likely to lead to inbreeding within each industry, resulting from localized recruiting and narrow specialization. But, while giving the young men their first taste of experience, industry can furnish the educational connecting links which are necessary for the widest application of education to the solution of practical problems.[5]

OUTLINE AND HISTORY OF GENERAL ELECTRIC TRAINING COURSES

No young men are allowed to be simply observers. There is no easy path to effective knowledge; only sustained hard work under able leadership can achieve it. The company believes that during this postschool period, young men should have the stimulus of feeling that they are no longer simply students, but are responsible members making their contribution and earning their pay.

While the young men are doing useful work they are given opportunities to take various courses which will help them to see the relationship between what they have learned in college and the work of the company. These courses also teach them new things which are directly related to the work they are likely to find an opportunity to do later on.

Young men, recruited for the company from engineering colleges, academic or business colleges, and high schools, enter through the Test Course, the Business Training Course, or the Apprentice Course. The opportunities awaiting them in study courses and kinds of work are shown diagrammatically in Chart 1.[6]

Test Course. The Test Course, which the company has operated almost since the beginning, is in itself a most valuable training for work in industry. All engineers work in the "test" during their first year with the company, gaining practical experience with different kinds of equipment. The object is to give the young men an intimate practical familiarity with the operation of apparatus. The young men are completely in charge of this work. The emphasis is on training for responsibility.[7]

Advanced Course in Engineering.[8] This course was organized in the fall of 1923 by R. E. Doherty and A. R. Stevenson, Jr., and gives intensive training in the application of fundamental engineering principles to the solution of practical problems. The graduates of this course have outstanding analytical ability, combined with engineering judgment obtained from experience on assignments in several different departments. Only a limited number of men can take the Advanced Course.

General Course.[9] The General Course was founded about 1928 to give a broader, less specialized training for design and application engineering to all the test men who are not enrolled in one of the more specialized courses. This course is divided into the Electrical Section and the Mechanical Section. Any engineering graduate in the company can take either of these two courses. Also hundreds of men from the drafting departments have taken the Mechanical Section. A Business Section is given in parallel with the engineering sections to provide knowledge of the organization and business methods of the company.

Sales Engineering Course.[9] This course was arranged in its present form in 1933. It is especially planned to benefit young engineers who have special aptitude for sales work. Salesmen must first be good engineers. The sound principles of application engineering are followed by special training and varied experience so that this relatively small group may be fitted to cope with its special problems.

Mechanical Design Course.[10] This course was organized in 1937, specifically to assist in discovering, training, and helping to develop the qualities of ingenuity, inventiveness, and originality. These talents are very valuable wherever possessed and

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[3] Engineering General Department, General Electric Company, Schenectady, N. Y.

[4] "Experience and Education," by John Dewey, Macmillan Company, New York, N. Y., 1938, pp. 47–50.

[5] The co-operative courses in which undergraduates get an opportunity to work in industry have this same advantage.

Presented under the auspices of the Engineers' Council for Professional Development, at the Semi-Annual Meeting, Kansas City, Mo., June 16–19, 1941, of The American Society of Mechanical Engineers.

[6] This chart is modified from an article, "Post-College Engineering Courses Within Industry," by T. C. Johnson, *Sparks*, Yearbook of Course VI-A, Massachusetts Institute of Technology, Cambridge, Mass., June, 1941.

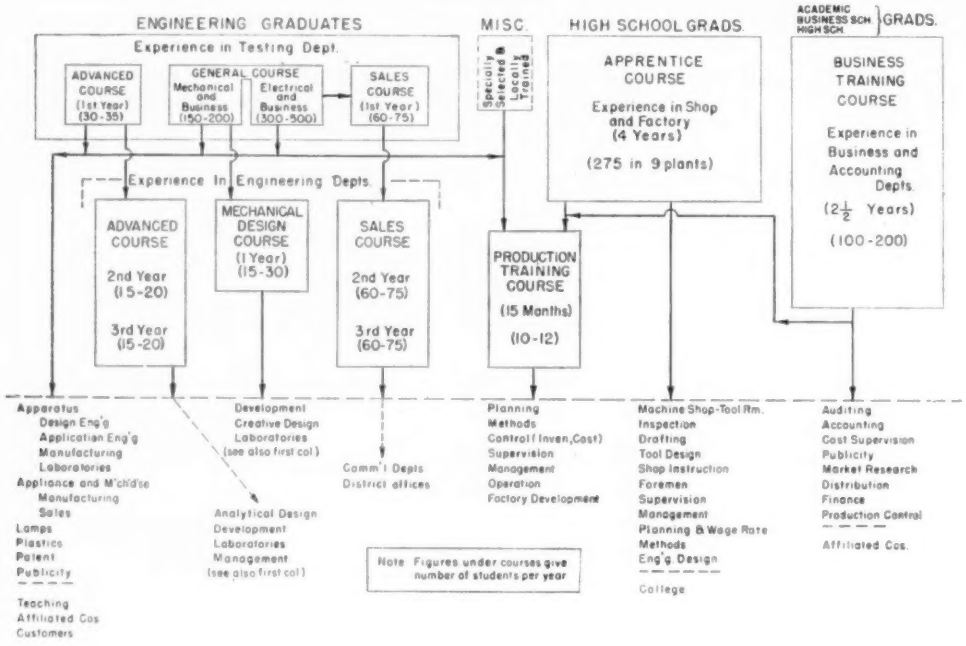
[7] "Training for Leadership in Industry," publication No. GES-2010-A; copies may be obtained from the General Electric Company, Schenectady, N. Y.

[8] "An Advanced Course in Engineering," by A. R. Stevenson, Jr., and Alan Howard, *Electrical Engineering*, vol. 54, 1935, pp. 265–268.

[9] Papers describing these courses in detail are planned for the near future.

[10] "Encouraging Creative Ability," by A. R. Stevenson, Jr., and J. E. Ryan, Mechanical Engineering, vol. 62, 1940, pp. 673–674.

CHART 1 TRAINING AND PLACEMENT OF YOUNG MEN IN THE GENERAL ELECTRIC COMPANY



applied; whether to mechanical, electrical, or even electronic apparatus.

Business Training Course.[11] Organized in 1919, this course has provided experience in the accounting and business-management side of the company for graduates of liberal arts colleges and schools of business administration. A thorough grounding in the principles of business and company policies and background is given over a period of two to three years during which practical experience is obtained on a variety of work assignments.

Apprentice Courses.[12] These courses have been on an organized basis since 1901, and offer training in several different trades for high-school graduates. Along with their practical work, they are given a course of study covering the necessary technical subjects. Because of their careful selection and thorough training, graduates are in great demand. Those showing outstanding ability and aptitude are assisted in securing scholarships to college, thus giving them the opportunity to balance their practical training with advanced technical knowledge; invaluable engineers often result.

Production Training Course. Since 1936, this course has given opportunity for a few carefully selected test men, Business-Training-Course men, apprentices, and men, trained at local works of the Company in production and operation activities, to study thoroughly by experience the tremendous organization required of a modern manufacturing company. The goal is an intimate knowledge of the personnel, planning, layout, ordering, scheduling, and all manufacturing details.

Any young man entering these courses may, therefore, look forward to a very wide field in which his talents may later be profitably utilized. (Refer to partial list in Chart 1.)

NOTE: The figures given under the name of each course in the chart show the approximate numbers of students normally enrolled in each course each year. Some years the total in all courses has run over 2500, not including other more specialized courses which are given by many of the individual departments in the company. This indicates the magnitude of the educational projects. In this connection it should be realized that the General Electric Company not only trains men for its own widely varied departments but also for its associated companies and has always been very generous in furnishing trained men to its customers wherever its very varied kinds of apparatus are used.

[11] "An Internship in Business," publication No. GEB-57-D; can be secured from General Electric Company, Schenectedy, N. Y.

[12] "Men for Tomorrow's Machines," by R. E. Ellis, *Mill and Factory*, vol. 27, Sept., 1940, pp. 83–86, 192, 194, 196, and 198.

EDUCATIONAL METHOD AND PHILOSOPHY

The operation of the different courses is in agreement with John Dewey's[13] statement that if theory is taught separated from practice, it is almost impossible to expect the student to apply the theory to practical problems, whereas if the theory is taught in the first place by practical men in relation to practical problems, the student automatically learns how to apply the theory.

Thus emphasis must be placed on the reality of the questions asked the students and their efforts to answer them. Knowledge cannot be poured into students like water into barrels. The students must teach themselves by struggling with each concept and by convincing themselves of each truth learned. They must learn from their own experience.

This invaluable experience, obtained under the guidance of older men, is the principal kind of training for such courses as the Production Training Course while for other courses it is the essential part which gives perspective to the classroom studies.

In the Rotating Assignment Programs of the Advanced and Mechanical Design Courses, the same bond between theory and practice is secured by assigning the student engineers individually to work for various leaders in the regular engineering departments of the company. All the men in the courses are making such contributions that there is little difficulty in persuading departments to accept their salaries while they are on approximately three-month assignments. The men thus can realize that they are contributing their share to the real work of the company.

For example, an electrical engineer might be assigned to the Induction Motor Department to work out some of the more standard machine designs and to help on an investigation of the effect of new punching designs in squirrel-cage rotors. A thermal engineer might be assigned to the Turbine Engineering Department to work on problems of stability of turbine governors. A high-frequency engineer might be assigned to a laboratory to assist in research experimental work on television. Students in the Business Training Course would have corresponding assignments. The variety of viewpoints and the experience gained in these assignments are very helpful when the

[13] "How We Think," by John Dewey, D. C. Heath and Company, Boston, Mass., 1933, pp. 52 and 53. "The assumption that information which has been accumulated apart from use in the recognition and solution of a problem may later on be freely employed at will by thought is quite false. The skill acquired with the aid of intelligence; the only information which, otherwise than by accident, can be put to logical use is that acquired in the course of thinking. Because their knowledge has been achieved in connection with the needs of specific situations, men of little book learning are often able to put to effective use every ounce of knowledge they possess; while men of vast erudition are often swamped by the mere bulk of their learning, because memory, rather than thinking has been operative in obtaining it."

student finally is placed in a department. The friends made during this period are lifelong.

In engineering courses the "physical picture" of what happens is emphasized instead of elaborate mathematical analytical theories for most of the courses. The emphasis is on good understanding of fundamentals and the use of common sense in the application of electrical and mechanical equipment.

Problems are chosen from practical cases which have arisen in the work of the company. For the advanced classes, in many instances, these are unsolved problems of ingenious design or analysis which the classes are asked to help solve.

Whenever a good occasion arises the regular program is temporarily abandoned in favor of some pioneering problem or investigation which has arisen in one of the engineering departments. In such a case, the whole class works as a group under the general guidance of the interested engineer. For example, the Electrical Section of the Advanced Course might be asked to investigate magneto operation and design.

A study of magneto operation might teach nearly all of electrical-machine theory. Magnetic and flux-plot calculations with the solution of voltage-generation problems would be needed. As obstacles were encountered, the class would have to study inductance, two-axis theory, current transients, traveling waves, and possibly radiation and shielding.

During the last third of the Mechanical Design Course, each man works on one or more inventive design projects of his own. Working samples of the designs may be constructed in spare time or in a well-equipped machine shop at the local technical high school. These projects are good indicators of the direction as well as the magnitude of a man's ability.

Accurate, complete, and to-the-point presentation of ideas in both speech and writing is so important that nearly all courses have sections teaching public speaking, letter writing, and report writing. These subjects are "learned by doing," as is everything else.

LEADERSHIP OF THE COURSES

"Engineers reach the limit of their usefulness from defects of character rather than from want of technical attainments. Our greatest difficulty is to find courage, candor, imagination, large vision, and high ambition."[14]

Both the Test Department and the educational staff of those courses which do not require years of experience to direct, consist almost exclusively of young engineers only a few years out of college. Some of them carry executive functions and thus get a training which is not often available in any other department. It has been our experience that the young men who are given these opportunities in practically all cases rise to the requirements and very efficiently carry the responsibilities placed upon them.

The supervisors (instructors) of the classes are all young men who have just finished the same course a year or two before. They are learning with the class (in fact they say they learn twice as much when supervising as they did when they took the course the first time). They are leaders in the search for knowledge rather than professors. The practical engineers and heads of the factory are the professors.

The availability of older men for furnishing information and giving advice is the essential ingredient that makes this unusual training organization possible. The educational groups of the company do not try to do more than a small part of the educational work. They call upon the practical engineers who are applying certain theories to give lectures and help teach the young men how these theories may be applied practically.

[14] From the corridor of the Dunham Laboratory at Yale, by Colonel H. G. Prout: an Engineer, a Soldier, an Editor, and an Industrial Executive.

Then also a large part of the education is not in the classroom at all but is gained by the student engineers in their daily work in engineering departments, by the Business-Training-Course men in the business offices, by the apprentices at their machines or drawing boards, and by the Production-Training-Course men in the shop and factory offices. In each case the students are under the supervision of practical men who have been awakened to their educational responsibilities.

One of the most important functions of the educational staff is to keep the older heads of sections interested in education. For this purpose, informal luncheons are held from time to time where different groups of the older engineers and officials, under whose direct supervision the young men work, are encouraged to discuss the educational program and the progress which the individual students assigned to them are making.

This has the added advantage of giving both the older men in charge and the educational staff a many-sided view of each student's progress, which helps to build up a clearer picture of what the individual student's abilities and aptitudes are, and thus helps immeasurably in eventually placing him where he will be happiest and do the best work. The students are often invited to other meetings in order to broaden the friendship and acquaintanceship between the older and the younger men.

Thus, no young man is allowed to get the feeling that he is lost in a big organization. He very promptly becomes a real personality to the older men who are directing his work and trying to help educate and place him where he can be most useful.

RESULTS OF TRAINING PLAN

The broad and thorough training of these courses results in a demand for the graduates in a diversity of positions. In Table 1 are examples of the variety of work done by Advanced-Course and Apprentice-Course graduates, respectively. Table 2 shows the large number of keymen who have come from the Apprentice Training Course from one company works alone, in the forty years of its existence.

The quality of the courses is very high because of the demand for capable men, the advantages of selection, and the availability of experts in many fields. The High Frequency Section of the Advanced Course probably is at least the equal of some of the best graduate courses in any college. Much of the material in the Mechanical Design Course and Mechanical General Course is simply unavailable elsewhere.

Placement of the graduates is easy because the effort of selection for the courses and the constant supervision during the year gives an intimate knowledge both of interests and of abilities.

A word about the selection process is important here. College graduates, both engineers and fine-arts students, are chosen for the Test and the Business Training Course largely on the basis of college performance and a personal interview. High-school graduates are chosen similarly for the Apprentice Course. The personal interview remains the most used means of selection, but some courses use additional helps. The Advanced Course gives an entrance examination in the nature of an aptitude test for technical engineering. The Sales Course has sometimes used a group of aptitude, achievement, intelligence, personality, and interest tests. The Mechanical Design Course depends largely upon ability demonstrated by assignments which demand the capabilities wanted.

All courses ultimately choose their members on the basis of the following:

1 Intelligence.
2 Business (or engineering, or mechanical) sense.
3 Energy or willingness to work.

4 Personality (including ability to get along with fellow workers and others).

5 Appearance; tidiness.

6 Leadership; the ability to organize, supervise, and inspire the actions of others.

It has been said: "It is rather costly to develop executives by having them practice on the organization." Both the Test Department and the educational staff of the courses are made up largely of young men who thereby obtain valuable executive training. Experience in planning for groups and assistance with personnel and budgetary matters are given these men. Performance in later years has fully justified the placing of these added responsibilities on them. Many of the graduates are in leading engineering, managerial, or executive positions.

TABLE 1 RANGE OF WORK IN WHICH ADVANCED-COURSE AND APPRENTICE-COURSE GRADUATES ARE ENGAGED

Advanced-Course Graduates;[a] All Classes

	Per cent
Engineering design	40.1
Laboratories	5.2
Commercial and applied engineering	5.2
Manufacturing	0.9
Patent Department	2.2
District Offices	3.1
Affiliated companies	0.9
Temporarily in training courses	8.1
Still in Testing Department	1.7
Left company (including Army and Navy, but not teaching)	27.1
Teaching in colleges	5.1
Deceased	0.4
Total (500 men)	100.0

Apprentice Graduates[b]

(Years 1936 through 1940, only)

Machining and toolmaking	43.1
Drafting	5.6
Tool design	7.0
Inspection	2.2
Shop instruction	0.9
Foremen	5.5
Planning, wage rate, methods	19.2
Test	0.6
Powerhouse operation	0.2
Cost	0.4
Checker	0.4
Production	0.4
Waste and spoilage	0.2
Engineering	0.4
Sales	0.2
College	4.4
Transferred to allied plants	0.7
Left company (including Army)	8.1
Deceased	0.4
Total (543 men)	100.0

[a] Percentages shown for all graduates. Of the men finishing 3 years of the Advanced Course, only 16 per cent have left the company, and one third of this number are teaching.

[b] This part of Table 1 gives the figures for the years 1936–1940 only. Organization figures show a great many key positions, such as plant managers, general superintendents, general foremen, etc., are held by apprentice graduates. Table 2 gives figures for Schenectady only for the years 1901–1941. Of the 2400 apprentice graduates in Schenectady since 1901, 1400 are still working and with the company.

TABLE 2 APPRENTICE GRADUATES IN KEY POSITIONS

Graduates from Schenectady Works only, 1901–1941

Managers, superintendents, and owners	32
Foremen	207
Inspectors	48
Wage rate and planning	144
Designers	221
Engineers	77
Instructors	47
Total	776

SUGGESTIONS

Just as in thermodynamics there are certain irreversible processes, so it may be said in general that young men leaving college can profitably enter the training courses of a big company, and later if desired, go to a small one. It is very seldom that a man starting with a small company gets a good chance to go with a large one later. This is largely because the big companies hesitate to bring in outsiders and place them on the ladder ahead of the young men who start at the bottom and work their way up.

There is sometimes a feeling that only the large companies can afford to carry on postcollegiate education. Perhaps in passing, the authors might be pardoned for urging that small companies should also realize their responsibilities in helping young engineers to bridge the gap between theories learned in college and their practical application in industry. There is a famous remark attributed to James A. Garfield:[15] "My definition of a university is Mark Hopkins at one end of a log and a student at the other."

Even if the small industry has only one engineer, that engineer, if he realizes his responsibility, can train the few young college graduates that the small company hires, just as a generation ago in Europe, each small machine shop trained its mechanics. The fact that every good executive must to some extent be an educator should not be forgotten. In this day of overspecialization the practical engineers and executives must not be allowed to feel that postcollege education can be carried on only by an elaborate organization of educators. The most important part of postcollege education is that which must be carried on by practical engineers and executives who have a genuine appreciation of their educational responsibilities.

CONCLUSION

Each industry must continue the education of its young engineers along its own specialized lines, whether formally or informally. Continuous progress demands continuous education of new talent and development of new ideas. The only hope of being able to stay with the front rank rests in the farsighted education of men to do the pioneer engineering.

In each of these courses, emphasis is laid on the fact that no single ability is sufficient,[16] but that each man must develop a broad knowledge of associated fields and, most important, a personality and method of working which allows him to coöperate effectively with his fellow engineers and the other departments. In the words of William E. Wickenden,[17] president of Case School of Applied Science: "Every calling has its mile of compulsion, its daily round of tasks and duties, its standard of honest craftsmanship, its code of man-to-man relations, which one must cover if he is to survive. Beyond that lies the mile of voluntary effort, where men strive for excellence, for unrequited service to the common good, and seek to invest their work with a wide and enduring significance. It is only in this second mile that a calling may attain to the dignity and the significance of a profession."

[15] According to well-established tradition, James A. Garfield is quoted as having made this remark at an alumni dinner in New York City in 1872.

[16] "How Collective Genius Contributes to Industrial Progress," by K. K. Paluev, *General Electric Review*, May, 1941.

[17] From an abstract of an A.S.M.E. address, "The Second Mile," by W. E. Wickenden, appearing under the title, "What Is a Profession?" in Briefing the Record Section, MECHANICAL ENGINEERING, April, 1941, p. 297.

The PROBLEM *of* INVESTMENT *in* 1942

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SELDOM, if ever, in the history of American finance has the task of investing accumulated funds been as difficult as it is at the present time. Rarely have so many perplexing problems and bewildering uncertainties confronted the investor, whether that investor be institutional, fiduciary, or individual. Investment involves the commitment of funds to productive use, under conditions that represent a minimum of risk and with reasonable promise of an adequate return on the sums so committed. Since there is no such thing as an absolutely riskless commitment, it has sometimes been said that all investors are speculators. Still another expression of the same sort is the oft repeated assertion that "an investment is a speculation that proves to be successful." Granted that there is and always has been a measure of truth in such statements, they do nevertheless violate the basic idea that prevails in the mind of the investor, which is to deal only with the known. To the speculator is left the effort to take advantage of the unknown.

Moreover for all practical purposes, most of us must rely on others when we invest. It is, of course, still possible for one to invest in his own business, in a home or a farm, or a piece of income-producing real estate for example. But for most persons such commitments are either entirely impracticable or at best extremely limited. For the trustee, the bank, the insurance company, or the private individual, practically the only available opportunity for investment is to be found in the security markets—corporate or government issues. Now corporate managements, being for the most part hardheaded and realistic individuals, are disinclined to make business commitments unless they can foresee with reasonable certainty some distance into the future. As the year 1942 opens, such discernment of future developments is almost at the zero point. About the only certainty that exists today is the certainty that the unexpected will come to pass. And so it has come about that for a number of years past and most emphatically at the present time, because of the war influence, those to whom investors would ordinarily turn to loan their accumulating funds, are in retreat. New capital issues have almost ceased to be. Investors scramble in mad competition for existing issues, forcing their prices ever higher and bringing the yield ever lower, or turn to the only remaining vehicle at hand—the ever-rising flood of government bonds. And so it may be seen that the dilemma of the investor is at bottom the dilemma of the would-be borrower—the demand side of the market for available capital funds.

FEWER POTENTIAL BORROWERS

Here follow some of the reasons for this retreat among potential borrowers, together with certain obvious pieces of evidence that our capital markets are completely out of balance. Perhaps as convincing a bit of evidence as one could find for the truth of the latter statement is the prevailing interest rate both for long- and short-time money—especially the latter. A glance at the financial page of any daily paper will reveal a rate for prime commercial paper of about $^1/_2$ per cent or $^5/_8$ per cent per year, and loans of large amounts have been made during recent months as low as $^3/_8$ per cent. One of the large packing companies recently borrowed for a period of nine months some $10,000,000 at the rate of $^1/_2$ per cent per annum. And in the field of government finance, certain bonds as they approach maturity actually have sold in the market at a minus yield—purchasers paying a premium for the privilege of carrying them to maturity. This latter circumstance is explainable by the fact that possession of such bonds guaranteed the holders a larger allotment in future Treasury offerings than they could otherwise have obtained. Hence the premium amounted to a price paid for a later purchase privilege. Such a situation is indeed a revealing exhibit of the glut of idle funds seeking an outlet; more especially since the bonds that would be purchased later would bear as a rule not more than $1^1/_2$ per cent or 2 per cent for from seven to twelve years.

Savings banks have been compelled to reduce the rate paid on savings deposits to an average of from 1 per cent to 2 per cent, depending on the part of the country where located. Commercial banks have long since ceased paying any interest on deposits of any amount. Insurance companies are adjusting their premiums upward while at the same time adjusting annuity rates downward. Month after month in an almost unending stream, the stronger corporations have put out 3 per cent to $3^1/_2$ per cent (in a few cases even lower) refunding bond issues for the purpose of calling and retiring higher coupon bonds of earlier dates. One such issue of $90,000,000 offered by one of the largest and strongest companies bore a $2^3/_4$ per cent coupon, sold at a premium, and was bought privately by a group of insurance companies without resort to the investment bankers. Example could be piled on example to illustrate this wholly abnormal and perplexing condition in present-day capital markets; and their very citation indicates the baffling nature of the investor's problem. A recent rather careful calculation suggests that there is in the United States immediately available not less than $20,000,000,000 of loanable funds, not to mention the almost fabulous possibilities that exist for expanding credit.

CAUSES OF REDUCED AMOUNT OF NEW CAPITAL ISSUES

What now are the more important causes that have produced the condition described above? What prospect is there that the way of the investor will be made less difficult in time to come? To answer the first question with any measure of adequacy would require time and space far beyond the limits of this paper. To answer the second question at all will require that the writer shall, in the vernacular "stick his neck out." Without attempting to analyze the first question adequately, one may cite certain potent influences that have contributed and are contributing to the lack of private corporate borrowings with its accompanying condition of retarded business expansion and its further limitation on investment opportunity. The easy (and in some quarters welcome) explanation would be to declare that private capitalism is all through, that these abnormal circumstances are but the out-

ward evidence that it is going through its death throes and that there never will be any return of private demand for private capital. Such an explanation, to be accepted, would demand more evidence than is yet at hand; and while it may someday prove to be correct, it must be dismissed for the present as too extreme a conclusion to be drawn from the admittedly disturbing influences that have been and still are at work. These influences are both economic and political.

On the economic side, first place must be given to the catastrophic effects of the world-wide deflation and depression that took place during the 30's. Without discussing reasons, it may be stated as a fact that a credit structure of unprecedented magnitude and world-wide in scope collapsed during the early years of that decade. Such a collapse involved so many people, created such widespread distress that endured for such a long time, and was accompanied by such revelations of corporate excesses and abuses, that a demand for political reform and political assistance for the needy became inevitable. Offering as it did unusual political opportunity, this demand was translated into action. It emerged in a mass of reform legislation, an assumption of far-reaching business controls by government agencies, a powerful strengthening of the hand of organized labor, and a corresponding weakening of what capitalistic managers had believed to be their rights and privileges. The average businessman will declare that these circumstances were the principal influences stifling his initiative. Controversy will never end as to whether business under different conditions would have moved into action and restored an inherently vital and aggressive economy to its normal state of activity. Controversy likewise will never end as to whether government policies during those critical years (pump priming, relief spending, and the like) operated to help or to hinder a return to capitalistic normalcy—or were intended to do so. Whatever the truth may be regarding these claims and counterclaims, statistical evidence reveals a quite negligible flow of new capital into private financing at any time since 1930, the while an increasing flow of government financing has been taking place.

IMPACT OF THE WAR

And now, added to the foregoing economic and political obstacles to business initiative, there comes the impact of a war economy with all of its bewildering uncertainties and its already alarming dislocations. Corporate management moves into war production, financed largely by the government but not marketing securities to the public. The investor continues to grope confusedly through the outstanding issues of stocks and bonds for a safe and remunerative vehicle for his savings. The insurance companies collect in premiums millions of dollars every day, seeking the next day for a place to put those millions at work. The savings banks of the nation witness a steady rise in their deposits and search for proper investments for them. Safe outlets daily become more scarce and yields become lower and, because there is nothing else to do, all parties turn finally to the steady flow of Treasury issues that are now outstanding in an amount around $60,000,000,000 with upward of $100,000,000,000 probable within the year, and positively astronomical figures to come if the war continues. Bank statements offer cold statistical evidence of the existence of the foregoing dilemma. From the largest to the smallest banks in the country, the story is the same—from 60 per cent to 70 per cent of their total assets represented by cash and government bonds.

Accompanying all this development, there is a steady increase in direct government investment in industry. In 1939, Federal agencies reported private manufacturing assets as having a value of about $21,000,000,000. Current plans call for about a ten-billion-dollar expansion of industrial facilities for war production. The government will itself finance most of this expansion—approximately nine tenths of it. Thus when it is all done, the government will own outright upward of one third of the productive manufacturing capacity of the nation. Add to this the further fact that the government is for all practical purposes sitting on each corporation's board of directors and dictating decisions on corporate policy, and one might conclude that a case has been made for the argument dismissed earlier in this paper—that private capitalism is on its way out. Not so. Remember always that this is a war economy. Future decisions by the American public will decide the kind of postwar economy that shall come into being.

All this does however affect vitally the problem of investment here and now. For one thing, its influence will be to persuade and impel all those fiscal agencies of government, now possessed of the most far-reaching financial powers, to keep interest rates down, so that the burden of our huge national debt will not be too crushing in the future. It is clearly apparent that so long as this purpose can be realized, just that long will those persons with savings to invest find the wages of capital correspondingly low and their investment opportunities correspondingly limited. The immediate future holds small promise of relief from this troublesome problem.

WHAT OF THE FUTURE?

What now of the longer-distance future? Assuming that an economy of free enterprise—even a greatly modified and government-regulated system of free enterprise—shall follow after our war effort has ended, it seems reasonable to expect that capital will return to something nearer its former economic importance and that interest rates will rise. This declaration is made in full awareness of a probable period of indecision and economic distress to follow the ending of the war. However, it must be remembered that, for the duration, an increasingly large proportion of our economic effort is to be war effort. This war is a war of machines. Machines of war are nonproductive in a peacetime economy and at all events are being destroyed and used up. This is true also for that portion of our plant still devoted to civilian needs. Moreover, it is probable that in the dislocations caused by the shift over to war production many smaller plants will disappear permanently from the economic scene. Then too it will probably come about that much of the capital equipment that is being dismantled in our larger plants to make room for war production will never be restored to its former use. Obsolescence and depreciation will dictate the replacement of such machines and equipment by the new and improved. What all this adds up to is that a diminished stock of available capital will be called upon to perform a Herculean task of postwar rebuilding. It is difficult to see how such a development can fail to offer more attractive rewards to the owners of the capital that will then be available. Interest rates will rise and investment opportunities will widen. After all, the law of supply and demand has not been legislated out of existence.

How does this affect the problem of present-day investment? Instead of simplifying that problem, it in fact complicates it. If the foregoing development does take place, the investor that buys now a 3 per cent bond or a 6 per cent preferred stock at $150 a share will almost surely take a loss in principal that will reduce his present modest income or even wipe it out entirely. If the foregoing development does not take place but, anticipating it, the investor buys short-term maturities on a 1 per cent or 2 per cent yield basis, he postpones indefinitely his opportunity to enjoy even the moderate return now available on long-term commitments. Truly the way of the investor, like the way of the transgressor, is hard.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Low-Temperature Physics

SCIENCE

GENERALLY speaking, any nation with a healthy interest in pure research is likely to have a vigorous industry, and vice versa, according to Prof. C. T. Lane of Yale University in an article entitled "Low-Temperature Physics in the USSR," published in *Science* for January 23, 1942.

In the special field of low-temperature physics Russian contributions both in the pure and applied domain merit special attention. At least two excellently equipped laboratories for such studies have been built in the last ten years. The best known of these is the Institute for Physical Problems at Moscow under the direction of P. L. Kapitza, but excellent work has been done at the Physico-Technical Institute at Kharkov under W. Schubnikov.

Kapitza, says Professor Lane, first appeared in England during the twenties at Cambridge, and, with Rutherford's backing, had very soon perfected an apparatus for the production of magnetic fields some ten times more intense than anything previously attained. About 1929, Kapitza's interest appears to have shifted to low-temperature work, probably because he recognized that such studies would be of prime importance in furthering our understanding of the metallic state. With funds supplied by Sir Alfred Mond he created, practically single-handed, the Royal Society Mond Laboratory at Cambridge for low-temperature work. Almost all the equipment at the Mond is of a radically new design, and special mention should be made of the Kapitza helium liquefier there.

This machine marks a new epoch in the technique of gas liquefaction, and for the first time opens up the region of extremely low-temperature research to smaller laboratories whose funds do not permit the expensive and highly specialized equipment previously necessary.

In a letter to Professor Lane in 1937, Kapitza stated that he had resumed his scientific work and seemed quite satisfied with his position in general. As head of the Institute at Moscow Kapitza has gone ahead in several directions in the low-temperature field. He has built another helium liquefier based on his Cambridge design and equally successful. Although no technical details concerning this plant apparently have been published[1] . . . . it is probably the best liquid-helium equipment in the world today.

A second outstanding piece of work has also come from his laboratory, and this merits our special attention since it apparently represents part of a widespread program in the USSR, linking low-temperature physics and industry. The Russians have instituted a new branch of engineering which they call "deep refrigeration," and much of this program appears to be under Kapitza's direction.[2]

This new industry is really an extension of one which has been practiced all over the world for a number of years (in one restricted field), namely, the production of oxygen, nitrogen, and argon from atmospheric air.[3] The Russians have been the first to realize that enormous quantities of valuable raw materials go to waste annually in various gases which are by-products of many industries. The problem has been to separate out the various pure components of these usually complex mix-

THEY FOLLOW THE JOB

(Five erection engineers whose combined experience in all parts of the world totals 145 years. Shown on the job at Grand Coulee Dam, they are, left to right, Sam P. Fisher, assembly foreman for Westinghouse Electric and Manufacturing Company; F. J. Malarkey, turbine erection engineer for the Newport News Shipbuilding and Drydock Company; H. Walter Berkley, member A.S.M.E., erection superintendent for Westinghouse; F. A. Smith, erection engineer for the Woodward Governor Company; and J. A. Radletz, transformer erection engineer for the General Electric Company.)

[1] A photograph of the plant appears in "Twenty Years of Soviet Physics," by A. E. Joffe, Physikalische Zeitschrift der Sowjetunion, vol. 12, 1937, p. 497.

[2] "Present-Day Science and Technology in the USSR," by J. D. Bernal, *Nature*, vol. 148, September 27, 1941, pp. 360–361.

[3] "New Process for Liquefying Air," by J. H. Awberry, *Nature*, vol. 148, July 5, 1941, p. 14. Also MECHANICAL ENGINEERING, vol. 63, December, 1941, p. 913.

tures and so make available to the chemical industry an abundant source of raw materials for the manufacture of plastics, synthetic rubber, etc. Low-temperature separation, i.e., the progressive liquefaction and removal of the various components of a mixture made possible by the fact that each component has a different liquefaction temperature, has been found to be a very economical and practical method. It is clear, therefore, that any advance in the technique of gas liquefaction, while interesting scientifically, is likely to have an even greater industrial significance.

Kapitza, continues Professor Lane, has recently perfected a new type of liquefaction apparatus which is quite different from anything so far attempted anywhere. While it has officially been applied only to the production of liquid air, it seems certain that the Russians are making wide use of it in their chemical industry, probably in plants making synthetic rubber and explosives. The actual machine, which makes use of a special type of low-temperature turbine, is too complicated to be discussed in much detail in such an article as this, although some technical information is available.[4] The suggestion that a turbine might be a valuable type of machine for gas liquefaction is, to be sure, not a new one. It was originally due to the eminent English physicist, Lord Rayleigh, about the close of the last century. However, it soon became apparent that a practical turbine would have to run at an enormous speed, some 30,000 rpm, to be efficient, and at such speeds vibration becomes a serious problem. It remained for Kapitza to overcome these formidable technical difficulties, and the resulting apparatus appears from the published accounts to be very reliable and of exceptional efficiency. One enormous advantage lies in the fact that it operates at very low pressure while existing liquefaction equipment does not. This means that for large-scale equipment the cheaper and more efficient turbocompressor could be used in place of the cumbersome and expensive multistage piston compressors now employed. It is probably not too much to say that all existing low-temperature industrial equipment has been rendered obsolete by this development.

Another Russian physicist, M. Ruhemann, has recently published a most illuminating book on the whole subject of gas separation by refrigeration.[5] Ruhemann is a product of the Kharkov Institute and judging by the number of publications by him on the subject which have appeared in various English and Russian journals, he has also taken a leading part in the establishment of this new industry. The book is highly technical, but would certainly repay close study by anyone interested in this field.

One instance, apart from gas separation, of some of the problems which have been solved in the USSR should prove of interest to scientists in this country. The so-called "natural gas" found in and adjoining oil fields consists largely of methane. This gas is much superior to ordinary illuminating gas in calorific value, but, more surprising, it is an excellent antiknock fuel for internal-combustion engines. The difficulty lies in storage, since a cylinder designed for 150 atmospheres pressure weighs about ten times more than the methane it contains. However, a tank 20 × 15 × 10 ft could hold as much methane (liquid) as a two-million cu ft gas holder and would be immeasurably cheaper and less dangerous. The advantages of such a scheme are obviously very great—such stored gas would be of great value in emergencies or when sudden and heavy industrial demands on fuel gas occur.

Despite all this industrial activity in recent years, a good deal of purely "academic" research of high quality has come from Kapitza's laboratory. One such outstanding contribution was made during the current year and reported in the *Physical Review*. This had to do with the properties of liquid helium. Kapitza had earlier discovered that liquid helium at a temperature some two degrees above absolute zero (so-called Helium II) behaves like an "ideal" fluid, apparently possessing a vanishingly small viscosity or fluid friction. It appears from this latest work that Helium II flows in narrow channels without change in entropy and accordingly is truly a super fluid. We must therefore regard this substance as being unique—nothing like it has ever been previously observed. The significance of this discovery for modern atomic physics is likely to be of the greatest importance.

[4] P. Kapitza, *Journal of Physics*, USSR, vol. 1, 1939, p. 7.

[5] "The Separation of Gases," by M. Ruhemann, Oxford University Press New York, N. Y., 1940.

Electronic Micrometer

ELECTRICAL MANUFACTURING

AN ARTICLE in the October, 1941, issue of *Electrical Manufacturing* entitled, "Measuring to 0.000025 in. Without Pressure," describes the development of the Carson electron micrometer on which consistently repeatable precision measurements of soft, flexible, or compressible materials can be made with the same accuracy as those on hard metal parts.

The instrument consists of a specially constructed micrometer mounted vertically in an insulated bushing over an anvil in a table-type "C" frame. A four-wire cable connects with the electronic device which is housed in one half of the carrying case. This unit contains two tubes—a rectifier and a pentode amplifier—a relay, and one control knob which serves to adjust the contact current to zero. Once properly set for the tubes used, no further adjustment is necessary.

In measuring dimensions of metal or conducting materials the micrometer tip is brought down into direct contact with the work. Contact is indicated by the click of the relay and the lighting of two lamps—one on the panel of the electronic unit and one in the micrometer stand. It is of academic interest that contact is indicated when the air gap is reduced to two or three millionths of an inch.

Two sizes of micrometer dial are available—one graduated to 0.0001 in. and one to 0.00005 in. With the large dial the instrument will repeat well within half a division or 25 millionths of an inch. A vernier screw is provided for making the final adjustment.

The open-circuit voltage between the anvil and micrometer tip is about 2 volts, too low for electrostatic attraction to cause light materials to cling to the contact point, and the closed-circuit current is zero so that there can be no pitting of points or material due to arcing when the contacts are opened.

For measuring soft or compressible materials, most of which are nonconductors, a contact member or rider is interposed between the work and the micrometer tip. This rider is connected to the instrument frame with a flexible wire coil and measurement is indicated when the tip makes contact with the rider. Various types of riders are available for different materials.

A number of unusual measuring problems have already been met during the development stage. For example, precision measurements of paper thickness are essential in the manufacture of electrolytic condensers. With the electronic micrometer accurate measurements are being made on single sheets of paper no thicker than half a thousandth. Aluminum foil used in the same application can be directly measured for thickness. Paint-film thickness can be measured without indenting the surface. Enameled wire can be measured for diameter and out-of-round, even for wires as small as 0.001 in. diam. Photographic-film thickness can be accurately gaged, and the effect of humidity

on the emulsion thickness measured. Relatively soft transparent plastic materials such as cellulose acetate and polystyrene can be measured without deforming or damaging the material. Linoleum, cork, felt, leather, fabrics, and other compressible materials can be measured with sufficient precision to disclose variations in dimensions and product qualities that heretofore were unknown or unsuspected sources of trouble.

Ball-and-Bucket Viscometer

ENGINEERING

A NEW type of viscometer, the results from which are given in units of dynamic viscosity and not in seconds and which, it is claimed, is free from the objections made to the efflux type of viscometer, is described in an article in *Engineering* for January 2, 1942. It is known as the Dobbie-McInnes ball-and-bucket viscometer.

In Fig. 1, the ball is indicated at *a*, and the bucket at *b;* the ball is fixed and the bucket is free, and the vertical movement of the bucket is limited by the table *c*. In the position in which these parts are shown, the table occupies what is almost its lowest position and the bucket is seen at the instant of dropping from the ball, when a test is just being completed. At the commencement of a test the table is raised to support the bucket, previously filled with the liquid up to the enlargement of the bore, and the ball is in contact with the bottom of the bucket. When the table is lowered the bucket falls at a rate determined by the viscosity of the liquid which passes through the narrow annular space between the smaller bore of the bucket and the ball.

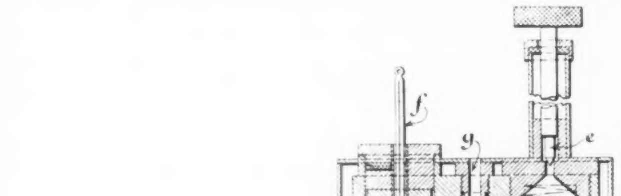


FIG. 1

It will be seen that the ball is screwed onto the end of a tube attached to a plug *d* that closes the chamber containing the ball and bucket. The plug, tube, and ball are removable as a whole for charging the instrument for a test. This operation consists of filling the bucket with the liquid up to the top of the smaller bore and then pushing the ball into it as far as it will go, so that part of the liquid is displaced into the larger bore, and the ball is completely submerged and in contact with the bottom of the bucket. The assembly is then placed in the chamber of the instrument with the bucket resting on the table, which is held up by a wood block or other convenient material so that the flange of the block *d* is about $^1/_{32}$ in. above the top of the body.

This position is temporary only and is adopted to insure contact between the ball, bucket, and table during the heating of the liquid.

The precision of the heating is one of the advantages of the ball-and-bucket viscometer. The body of the instrument consists of a cylindrical block of metal of good conductivity in which are bored three holes, viz., the ball-and-bucket chamber on the left, a thermometer well in the center, and a heating element and thermostat chamber on the right. The body is enclosed in a sheet casing which provides a heat-insulating air jacket. The heating elements are of the electric-coil type, with the pitch of the coils closer at the ends, as indicated diagrammatically, to compensate for end radiation. The current connection is a three-point five-ampere plug in a combined socket and switch for either direct or alternating current at 250 volts. The heating assembly includes a thermostatic bellows element and the chamber is filled with medicinal paraffin. It is closed by a valve *e* which plays an important part in the temperature control. When the charged bucket is in place, a little olive oil is poured into the tube of the ball and into the socket *g*, a sensitive thermometer *f* is placed in the ball and a similar one in the well, the valve *e* is opened, and the current switched on. The readings of the two thermometers are then observed and when that of the thermometer in the socket approaches within 3 deg of the required test temperature, the valve *e* is closed. This operation brings the thermostat into action by confining the oil in its chamber. By this time the two thermometers show the same reading and the temperature of the liquid is, therefore, of the desired value. The liquid is heated by conduction through the ball and tube, bucket, and table, as all these parts are in close contact with one another and with the body. The heating is assisted by radiation from the walls of the chamber.

When the temperature readings are synchronized, the table is lowered slightly and the slot *h* in its spindle is engaged with the trigger *i*. The ball, bucket, and table are still all in contact, for the slight downward movement required for setting the trigger is provided by the seating of the flange of the block *d* on the body. The actual test is now proceeded with. The clock is provided with a starting rod projecting from both sides of its case toward the top. Pushing of this rod to the right starts the clock and simultaneously releases the table trigger, when the table immediately falls away from the bucket into the position shown by the full lines, with the end of its spindle resting on the pivoted striker arm *j*. The pivot of this arm carries a small toothed wheel meshing with a similar wheel to which is connected a finger *k*. When the table leaves the bucket the latter is suspended, by the viscosity of the liquid, from the ball and commences to fall, thus bringing the escaping liquid into shear. The descent of the bucket under its own weight is comparatively slow as long as the ball is in it, but, once the bucket is clear of the ball it will fall suddenly onto the table. The momentum imparted to the table spindle is sufficient to tilt the striker arm into the position indicated by dotted lines in Fig. 1. This movement pushes the clock control rod to the left and stops the clock.

The reading of the clock in seconds, when multiplied by the appropriate constant marked on the particular ball in use, gives the required viscosity of the liquid in absolute centipoise units at the temperature of the test. It is usual when making viscosity measurements to repeat the test several times in order to obtain an average value. In this respect the ball-and-bucket viscometer is probably the most rapidly operated instrument, since the liquid remains in the bucket and the temperature can be consistently maintained. There is thus no time lost in refilling or in temperature adjustments. Its handiness is enhanced by the facts that only a small sample of the liquid is necessary and that, since there are no tubes to be cleared, cleaning is easily carried out. The tubes employed in viscometers are usually of small diameter and are therefore easily affected by the presence of small particles of dirt or by a roughened surface. The annular passage of the ball-and-bucket viscometer, although narrow, has no such disadvantage, and the surfaces of both the elements are lapped very smooth. Actual tests are made to check the constant of each ball. There is no tendency for the bucket to take up an eccentric position in plan, relative to the ball; neither, since the passage is not a long parallel one, would it appreciably affect the results if there were contact between the two elements at any point. An annular flow tube, on the contrary, may be considerably affected by contact between the core and the wall.

The instrument described is known as the laboratory electrically heated type and is designed for use where precise results are required and testing is a part of normal routine. For testing in the field, however, Messrs. Dobbie McInnes provide an alternative much simpler instrument in a portable wooden case which can be set up as a stand. The ball and bucket elements are virtually the same as in the laboratory instrument but there is no body part and the liquid has to be heated independently to the desired temperature. The table and the automatic timing devices are omitted, and the timing is done by a stop watch or by a stop clock.

Industrial Uses for Silver

AMERICAN SILVER PRODUCERS' RESEARCH PROJECT

SILVER in a variety of forms has been made available without charge, on a consignment basis, to responsible manufacturers who are prepared to apply it intelligently in the solution of new research and development problems. Moreover, expert advice in the application of silver can be had for the asking through the American Silver Producers' Research Project in which most of the important American producers of silver are represented, and through whom the announcement was made public. An objective, of course, is to find new industrial uses for silver. Such applications have been growing rapidly for a decade.

SILVER ANSWERS SOME PRESSING METAL NEEDS

Manufacturers who are having trouble in securing copper, brass, stainless steel, and certain other scarce materials, especially for nondefense needs, may well give a thought to silver. There is sufficient silver available in world markets and its cost is lower than that of several other metals now being used in large quantities. Silver is easily worked and can be had in such forms as sheets, strips, rod, tube, and wire, not to mention other forms. A variety of alloys having diverse and useful properties are also available, as are certain metals clad with silver.

In parts of small size, and especially those which require much work in fabrication, material costs are often a small part of total cost even though the unit cost of the material is high. Silver often fits in well in such cases and may even enable manufacturing to continue when otherwise it would have to stop for lack of other metals. Silver always has a high reclaiming value and correspondingly increases the intrinsic value of the product in which it is used.

High resistance to corrosion and high electrical and heat conductivity are among the many important advantages of silver in industrial applications.

LEAD-SILVER SOLDERS TO CONSERVE TIN

Should tin supplies from the Orient be greatly curtailed or cut off, conservation of present supplies will become imperative. The use of tin-lead solders will doubtless have to be greatly curtailed. Two types of lead-silver solders containing no tin are finding increasing use. One of these is the eutectic alloy which contains $2^1/_2$ per cent silver and $97^1/_2$ per cent lead. It flows at about 580 F. The other is a proprietary alloy composed of 2.5 per cent silver, 0.25 per cent copper, and 97.25 per cent lead. It starts to melt at about 580 F and flows at about 661 F. These are relatively "soft" solders and should not be confused with the silver brazing alloys and "hard" silver solders having melting points of 1175 to 1600 F.

In suggesting the use of lead-silver soft solders for cans and other containers, it is pointed out that a lead-silver solder containing 2.5 per cent silver costs less than lead-tin solders in which the tin content is above 25 per cent. This is significant, since the much used tin-lead soft solders contain 50 per cent of tin. As the lead-silver solders have higher melting points than the lead-tin solders, higher temperatures can be applied in baking synthetic coatings used as linings, especially in beer cans.

USES OF SINTERED SILVER INCREASING

The use of silver in powder metallurgy is increasing. It is employed for making mechanical mixtures containing metals such as nickel which do not alloy with silver except in small proportions. Graphite, tantalum, molybdenum, and tungsten are among the materials mixed in finely powdered form with silver powder, compressed and sintered at a temperature slightly below the melting point of silver.

Some resulting products can be rolled into sheet or drawn into rod which are used, at present, chiefly for making electrical contacts and welding electrodes, though other applications are contemplated. Even wire suitable for heading operations is produced, since silver itself is ductile and helps to form ductile mixtures. It is possible to make mixtures almost as dense as might be expected if complete alloying were possible. On the other hand, if an ingredient which can be volatilized after pressing has been done is added, a uniformly porous product can be produced.

SILVER FOR BUS BARS?

Now that copper production can barely keep pace with defense needs, the use of silver in bus bars has been suggested and has more than academic interest. If government-owned power plants or even those of private companies replaced copper bus bars with those made of silver, thousands of tons of high-purity copper could be released for defense applications. The silver presumably would come from reserves now idle in government vaults or from newly mined silver which the government is constantly purchasing from domestic producers. It might be lent and returned later when needs for copper are less pressing.

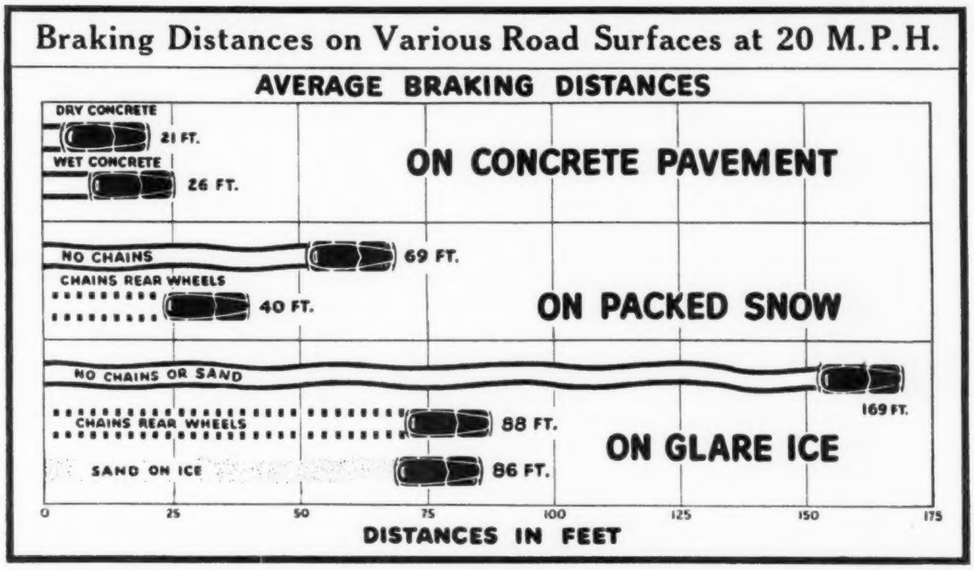
Silver, of course, is the best electrical conductor known and has other excellent physical properties suiting it for use in bus bars. It is easily fabricated and can be silver-soldered or brazed with silver alloys in the same way that copper bus bars are brazed.

SILVER ENGINE BEARINGS

Silver-lined bearings are now being used effectively in aircraft engines of the radial air-cooled type and also in engines designed for liquid cooling. Some of the bearings are complete rings coated inside and outside with silver and some are split and coated on the inside surface only. Silver is understood to be capable of carrying a higher load than babbitt, is a better conductor of heat, and retains its hardness at temperatures above those feasible with babbitt.

As far as is known, the coatings are applied by electroplating, although it is possible that other methods of application have been found suitable. Subsequent to application, the silver is understood to be machined to hold the close limits on dimensions required in aircraft work. Silver removed in machining and that applied on bearings which are damaged in process or may be rejected for minor defects is easily reclaimed, of course. All silver coatings on bearings in service are believed to be pure silver which, of course, has high corrosion resistance and is not attacked by corrosive agents sometimes found in lubricating oils. In this respect, the bearings are quite different from those made from cadmium alloyed with small proportions of silver and should not be confused with such alloys.

Although the silver coatings applied to bearings are understood to be about as thick as those of babbitt previously used, most silver coatings applied to metals for industrial and other uses are well under 0.001 in. in thickness and are low in cost because the quantity of silver used is small and is readily applied by plating and other means. New uses for such coatings are being found and are expected to multiply as their excellent properties for industrial applications become more widely known.



President Roosevelt's recent safety proclamation called on every citizen to cooperate in "preventing wastage of human and material resources of the Nation through accidents." Above is the new guide on braking distances for automobiles according to weather conditions affecting road surfaces, based on National Safety Council research. Over 3,000 tests were made on frozen Lake Cadillac, Mich., and snow-covered roads under direction of Professor Ralph A. Moyer of Iowa State College, chairman of Committee on Winter Driving Hazards. (Actual stopping distances are 22 feet more than each of the average braking distances shown above because it takes average motorist three-quarters of a second to react and apply brakes after seeing reason to stop. This means 22 feet at 20 miles per hour.) Study of chart may prevent needless deaths, injuries or costly property damages.

N.A.C.A. Annual Report

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

ON January 12 the National Advisory Committee for Aeronautics released a summary of its annual report, prepared by Jerome Hunsaker, chairman of the committee and fellow and past vice-president of The American Society of Mechanical Engineers. Excerpts from the summary follow.

The desired characteristics of the naval and military types of aircraft now included in the national-defense program are such that both fundamental and specialized research are necessary to realize the performance required.

The outstanding fighters of 1940–1941—the British Spitfire and Hurricane airplanes and the German Messerschmitt 109F—had maximum speeds of the order of 360 mph. The American aircraft program must provide new fighters for 1941–1942 of much higher speed. A speed of 400 mph and as much more as is practicable is an obvious necessity. The factors involved include not only clean aerodynamic design, but the discovery of new principles and facts whose application in design leads to real improvements. It is not enough merely to increase the horsepower and to smooth the surfaces.

It was necessary to develop a new wing section of low-drag type to obtain accurate data, in a low-turbulence wind tunnel, of its lift and drag, to determine the effect of various types of flaps for increasing lift, and the action of normal and other lateral-control devices. It was also essential to re-examine the method of cowling and cooling of both air-cooled and liquid-cooled engines at high air speeds. Special cowlings were required to handle the air needed to cool the engine, the oil radiator, the intercooler and, in the liquid-cooled type, the radiator. This work was based on theoretical analysis and proved in wind-tunnel and flight tests.

Propellers of usual design are inefficient at extreme speeds. New propeller-blade sections and new plan forms for the blade have had to be developed to keep the losses under those conditions to a minimum. Again theoretical studies and wind-tunnel tests together were necessary to arrive at a practical solution.

At high speed the airplane is subject to compressibility effects. The wing, the fuselage, the propeller, and other parts must be designed to eliminate compression waves as far as possible. This requires testing in a high-speed wind tunnel.

Altitude requirements have been much increased. They demand better supercharging equipment and better cooling of the engine and the intercooler at high altitudes.

In planning the design of a new military airplane special model tests are necessary to determine its spinning characteristics. Where the design is of a radically new form, tests are also made in the free-flight tunnel to be assured that the design will have adequate stability and control.

Research Facilities. The committee initiated its present program of expansion of research facilities in 1938. Through the support of the President and the Congress since that time, the committee has been able to place in operation during the last

year seven wind tunnels of major significance, and a structures-research laboratory, all now fully engaged on urgent problems relating to the defense program. The new wind tunnels at Langley Field are: A 20-ft free-spinning tunnel, a stability tunnel, a two-dimensional tunnel, and a 16-ft high-speed tunnel. At Moffett Field the new tunnels so far placed in operation include a 16-ft high-speed tunnel, and two 7 × 10-ft high-speed tunnels.

There are under way at Moffet Field a low-turbulence high-speed tunnel, a supersonic tunnel, and a full-scale tunnel.

An aircraft-engine research laboratory is under construction at Cleveland, Ohio. This will include: Special equipment for research on engines and accessories, propellers, fuels, and lubricants; an ice tunnel for the study of problems of ice formation in flight; and a novel, high-speed engine research wind tunnel to operate under conditions of temperature and density existing at high altitudes.

There is also under construction at Langley Field a second seaplane towing tank, a seaplane impact basin, an electric power-generating plant, an additional shop building, and extensions to the flight research laboratory and to the service and administration buildings.

In the present emergency the committee, with the special approval of the Congress, has increased its use of available research facilities in educational and scientific institutions and in the National Bureau of Standards. The work so done supplements that of the committee's own laboratories; and the committee's research contracts enable scientists of special qualifications to work upon problems of national importance which they would otherwise lack the means to investigate.

Relation of Research to Civil Aviation. With the exception of dive-bombing problems and problems incident to armament installations, practically all of the research of the committee is directly applicable to civil types of aircraft. Improvements in large two- and four-engine airplanes of the bombing type will undoubtedly be reflected in transport airplanes of tomorrow. New and improved engine installations, wing forms, and propeller designs developed for military types will be important factors in increasing the speed and efficiency of future civil aircraft.

Strengthening of Subcommittees. Under the law it is the duty of the National Advisory Committee for Aeronautics to "supervise and direct the scientific study of the problems of flight with a view to their practical solution" and also to "direct and conduct research and experiment in aeronautics."

To assist in the discharge of these duties and in the determination of present and future research needs of aeronautics, civil and military, the committee has established standing technical subcommittees composed of specially qualified representatives of the governmental agencies concerned and of experts from private life. The members of the subcommittees, like the members of the main committee, serve as such without compensation.

The subcommittees prepare and recommend research projects. Most of the projects recommended for investigation are assigned to the committee's laboratories. Some projects are assigned to the National Bureau of Standards and others to universities and technical schools, depending on where the necessary research equipment exists and upon the availability of a qualified staff. This policy makes effective use of existing research facilities, stimulates aeronautical research, and also has the advantage of training research personnel.

The technical subcommittees, now increased in number and strengthened in personnel, have been meeting with greater frequency. This has led to stimulation and clarification of thinking and to greater co-ordination of effort. In all, some 183 persons are serving on the various technical subcommittees.

In addition, frequent conferences devoted to special topics are held with engineers and designers from the industry who are responsible for parts of the defense program. These conferences bring members of the committee's scientific staff in contact with those who apply the results of their research work.

Turbine Locomotive

PROCEEDINGS, THE INSTITUTION OF MECHANICAL ENGINEERS

THE address by W. A. Stanier, president, before The Institution of Mechanical Engineers, entitled "The Position of the Locomotive in Mechanical Engineering," and published in the Proceedings, vol. 146, December, 1941, pp. 50–61, covers the development of the steam locomotive as the author has seen it from 1892 to the present.

In this comprehensive review, mention is made and some data are given on the "Turbomotive" which may be of special interest to American engineers:

The only "abnormal" locomotive type available for everyday active service in Great Britain, says Mr. Stanier, is the London, Midland and Scottish "Turbomotive" which substitutes in the simplest possible manner a turbine and gear drive for the normal reciprocating layout. No condenser is fitted, so the increase in basic thermal efficiency compared with a standard locomotive is small. There are possibilities, however, of more economical working at high power outputs, while the purely rotary working parts, being totally enclosed, may promote lower upkeep costs. This engine has now run 185,700 miles in express service, but data are not yet available for a final summing up of all the results. Some particulars of its fuel consumption are available.

DYNAMOMETER-CAR TEST RESULTS ON 4-6-2 TURBOMOTIVE, BUILT 1935

Engine no.	6202
Miles since last heavy repair	102,915
Average weight of train, tons	485
Average running speed, mph	55.0
Coal consumption:	
lb per mile	41.6
lb per ton-mile (including engine)	0.067
lb per drawbar hp-hr	2.78
lb per sq ft grate per hr	50.7
Water consumption:	
gal per mile	37.1
lb per drawbar hp-hr	24.8
Evaporation, lb water per lb coal	8.93

The National Roster

SCIENCE

MEMBERS of the A.S.M.E. will recall having been asked to fill out and file in Washington for the National Roster of Scientific and Specialized Personnel questionnaires covering their education and professional qualifications. In a third progress report on the activities of the Roster, published in *Science*, Jan. 23, 1942, Dr. Leonard Carmichael, the director, presents the accompanying table.

In connection with uses to which the Roster has been put, Dr. Carmichael says:

It is interesting that from this list already more than 50,000 names have been presented to various defense agencies and other government bureaus for consideration in connection with appointments. Almost all the requests that come to the Roster office are of a confidential character and it is not possible at this

TABLE 1 DISTRIBUTION OF INDIVIDUALS REGISTERED WITH THE NATIONAL ROSTER OF SCIENTIFIC AND SPECIALIZED PERSONNEL BY PROFESSIONAL FIELD AND EXTENT OF EDUCATION, SEPTEMBER 1, 1941

Field of specialization	Extent of education					
	Doctor	Master	Bachelor	4 Yrs. Coll. No Degree	Others	Total
Languages	2,785	1,607	1,598	116	566	6,672
Genetics	435	164	82	13	61	755
Zoology	1,500	975	597	28	294	3,394
Physiology	554	50	13	1	....	618
Botany	741	247	79	3	6	1,076
Bact., Immu., Path.	1,384	349	369	25	56	2,183
Anatomy	484	25	13	1	3	526
Tropical med.	245	30	18	....	5	298
Chemistry	7,345	7,378	19,093	1,242	3,394	38,452
Physics	2,507	1,679	1,335	82	218	5,821
Mathematics	1,502	1,838	880	31	44	4,295
Geology	932	1,020	1,996	147	484	4,579
Actuarial sci.	9	96	278	8	100	491
Speleology	17	6	13	2	26	64
Horology	....	....	16	2	663	681
Civil eng.	135	1,616	5,825	291	1,357	9,224
Marine eng.	4	76	313	51	269	713
Safety eng.	9	41	366	59	585	1,060
Traffic eng.	2	31	125	8	100	266
Radio eng.	108	348	905	73	704	2,138
Testing mat. eng.	70	211	567	36	237	1,121
Chemical eng.	331	595	1,915	138	317	3,296
Electrical eng.	228	1,339	5,402	219	1,205	8,393
Mechanical eng.	117	1,055	4,500	288	1,478	7,438
Motion Pict. eng.	2	12	69	9	124	216
Automotive eng.	48	215	1,047	99	1,145	2,554
Aeronautical eng.	55	328	1,627	139	988	3,137
Management eng.	103	309	1,136	98	1,114	2,760
Heating and vent. eng.	19	159	851	95	696	1,820
Mining and met. eng.	335	856	2,733	154	612	4,690
Economics	1,103	867	425	17	105	2,517
Accounting	1	42	176	36	393	648
Psychology	1,957	1,013	181	7	10	3,168
Anthropology	281	147	95	14	32	569
Hist. and pol. sci.	2,120	1,367	413	17	64	3,981
Personnel adm.	348	1,350	1,178	100	608	3,584
Speech pathology	70	110	39	....	10	229
Statistics	595	615	517	29	108	1,864
Geography	231	171	98	8	56	564
Sociology	472	301	133	4	23	933
Recreation leadership	33	311	650	52	185	1,231
Plant path., hort. and agr.	1,020	839	642	21	69	2,591
Forestry and range mgmt.	136	982	2,272	71	418	3,879
Animal sciences	350	684	5,887	57	259	7,237
	30,723	31,454	66,467	3,891	19,191	151,726

time to describe them. It can be said, however, that especially large numbers of demands have been presented for individuals in the fields of physics, electrical engineering, aeronautical engineering, marine engineering, and mechanical engineering. Significantly large numbers of requests have also been received for individuals with special language skills or with a combination of some other professional competency and language skill. There have been demands also for a good many economists and psychologists, and, indeed, there have been some requests for men in each of the fields covered by the Roster.

A few examples of the sort of requests which come to the Roster from nonconfidential sources may give an indication of the character of demands in the confidential areas as well.

The Bureau of Mines of the Department of the Interior requested names of chemical engineers skilled in extractive metallurgy, especially in the field of aluminum.

The Interstate Commerce Commission requested a transportation economist capable of assuming responsibility for conducting independent research and using statistical data in the investigation of the economics of transportation.

An investigating committee of the United States House of Representatives requested the names of experts in the fields of economics, sociology, transportation, and job statistics to perform research and analysis in connection with national-defense migration.

The Office of Price Administration and Civilian Supply requested a number of mathematical statisticians.

Engineers of various types have been requested for the Panama Canal Zone.

The Office of Production Management has requested, under specific description, more than thirty economists skilled in such fields as brass, cadmium, hides, rubber, cork, and miscellaneous metals.

The National Youth Administration requested the names of individuals eligible for appointment as radio engineers to provide advisory service to state administrators in connection with the training of young radio operators.

From the Securities Exchange Commission a request for statisticians in securities and corporate finance has been received.

Hydroelectric Power in Canada

DEPARTMENT OF MINES AND RESOURCES

THE annual review of hydroelectric progress in Canada, prepared by the Dominion Water and Power Bureau, Department of Mines and Resources, Ottawa, indicates the continued intensive efforts of the hydroelectric industry to meet the constantly growing demands for power for war purposes. These demands were met by the bringing into production of new water-power installations, by the construction of new transmission-line facilities and interconnection of existing transmission systems, by the diversion to primary use of large amounts of hydroelectric energy that had formerly been sold as secondary power for steam raising in electric boilers, and by the continuation of daylight saving during the winter months. Apprehension was caused for a time by midyear water shortages in certain areas but these were corrected by substantial precipitation in the later months.

The increasing demand for power is shown by the monthly figures of output of Canada's central electric stations as compiled by the Dominion Bureau of Statistics. For the 10 months ended with October the total output was more than 8 per cent in excess of the output for the corresponding period in 1940, and there is every indication that the total output for the year will reach a new record of more than 33 billions of kilowatthours. Of greater significance is the increase of 22 per cent during the first 10 months of the year in the power generated for primary use in Canada. This indicates the great increase in industrial activity due to war production and reflects the very substantial diversion of secondary energy to primary use to which reference has already been made. Compared with 1939 this diversion of secondary energy to primary use is equivalent to about 640,000 continuous horsepower.

New water-power installations during 1941 totaled 254,600 hp. This, together with 6000 hp resulting from equipment replacement not previously reported, brings Canada's total hydraulic installation as of January 1, 1942, to 8,845,038 hp. There are, as well, other undertakings under way which should add more than 650,000 hp to this total during the next year and a half. Transmission-line extensions and interconnections of existing systems carried out during the year were of the utmost importance in facilitating the effective exchange of hydroelectric energy in certain areas, thereby utilizing available power supplies to the greatest advantage for increased war production.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Coal-Handling Systems

COMMENT BY C. B. BRIGGS[1]

In his paper,[2] the author mentions a remote-controlled electric locomotive in use for switching and spotting at a central station.

There is a locomotive of this type in use at the Northeast Station of the Kansas City Power & Light Company. Since it has proved so satisfactory, it is felt that a brief description of the locomotive and its duties might prove to be of some general interest.

Coal is consumed at Northeast Station in amounts varying from 300 to 1500 tons per day. Since all of this coal is delivered by rail, the problem of moving and spotting the cars inside the yard is an important one. Two elevated tracks have been provided at the plant in order that incoming coal may be dumped from the cars directly into a hopper below. From this outside hopper, the coal is carried on a belt over the weighing apparatus to two separate bucket conveyers which carry the coal to the top of the boiler room where, in turn, it is distributed on belts to the individual bunkers.

Briefly, there are three distinct schedules of switching and spotting at Northeast:

1 The first and lightest of these schedules occurs for a period of approximately seven months, during the warmest weather when coal consumption is low, because of the large amounts of gas burned. This daily warm-weather operation includes switching and spotting from five to ten loaded coal cars over the unloading hopper, one at a time; removing one loaded ash car from the plant and replacing it with an empty. On this schedule, the locomotive is in motion about 45 min and travels approximately $2^1/_4$ miles each day.

2 The second schedule which occurs during normal winter operation requires the locomotive to remove from ten to fifteen loaded coal cars from the building where they had been placed the day before for thawing overnight and to spot these cars over the unloading hopper; to place from ten to fifteen loaded cars inside the building for use the next day; to remove one loaded ash car from the plant and replace it with an empty. While operating on this normal winter schedule, the locomotive used travels about 7.8 miles and is in motion approximately three hours.

3 The third and most severe schedule occurs in the winter on a few week days when no gas is available and a maximum amount of coal is consumed. During this schedule, the locomotive travels a minimum of 8.2 miles and is in motion at least $3^1/_2$ hours.

Until 1939, a 60-ton steam locomotive was used for these switching and spotting operations. The average cost of fuel and maintenance on this steam locomotive was \$4600 per year or about \$1.80 per hour of operation.

At that time, a study was made to find a less expensive method of moving the cars. Four new methods were finally suggested, each of which proved to be more economical than the full-time use of the steam locomotive.

The first idea considered was the installation of a cable-operated car haul on the elevated tracks for spotting cars over the unloading hopper. This device was to have a steel cable fitted with a car hook and operated between head and tail sheaves at 400-ft centers. The car puller was to be capable of exerting a sustained pull at a speed up to 50 fpm for starting and moving two 50-ton loaded cars plus three empties in either direction. The total cost of this car puller was to be around \$15,000. It would have released the steam locomotive for other service for a portion of the day but did not entirely eliminate its use.

The second plan was to purchase a remote-controlled alternating-current overhead-trolley locomotive to perform the same duties required of the car puller. This trolley locomotive would have cost about \$14,000, including trolley, and would have been superior to the car puller due to lower maintenance and less wear on the cars. However, its slow operating speed and the impracticability of installing 3-phase trolleys around the yard prevented its use elsewhere and the steam locomotive would still have been required.

A 50-ton Diesel-electric locomotive was considered in the third plan. It was to be operated in the conventional manner for switching, but it was also to be equipped with a 125-v a-c overhead trolley for operation by remote control when spotting cars over the unloading hopper. The Diesel-electric could not be operated by remote control when generating its own energy because of difficulties in engine governing. The cost of the locomotive, including a motor generator set and remote-control apparatus, was to be \$29,150. However, the cost of this plan cannot be compared with costs of the first two, since the Diesel-electric locomotive completely eliminates the use of the steam locomotive.

The fourth plan, and the one carried out, was the purchase of a 50-ton electric storage-battery locomotive having a combination remote-and-regulation-type control. This locomotive is equipped with a 600-ft self-retrieving control cable for connecting to a fixed remote-control station, located near the unloading hopper. The 96-cell 725-amp-hr battery is discharged in two 48-cell groups, connected in parallel for low-speed operation and in series for higher speeds with light loads. The cost of this locomotive was approximately \$24,000, including charging-station equipment. There are many outstanding advantages to be claimed for the battery locomotive at Northeast. No fireman is required and about three hours of one man's time is saved each day, while the cars are being spotted over the unloading hopper and dumped. The cost of power required is practically negligible, since charging is done at night during off-peak load conditions. The battery locomotive is also a dual-purpose unit as it is possible to do all the switching required between periods of spotting.

The new locomotive has been in service for nearly two years, during which time it has proved quite satisfactory. Because of the simplicity and ruggedness of design it is felt that maintenance will be very low. The total cost of maintenance and power for charging amounts approximately to \$1200 per year or 47 cents per hour of operation, including an allow-

[1] Kansas City Power and Light Company, Kansas City, Mo. Jun. A.S.M.E.

[2] "Coal-Handling Systems for Central Stations," by George C. Daniels, MECHANICAL ENGINEERING, November, 1941, pp. 801–806.

ance for battery replacement every eight years.

Since fuel and maintenance on the original steam locomotive amounted to \$4600, an annual saving of \$3400 may be claimed without considering the decreased costs of operating labor. If the saving of \$1060 per year due to decreased operating labor is added to this figure, the total annual saving becomes about \$4460. When a fixed charge of 12 $^1/_2$ per cent per year is used, the amount justified for this purchase becomes \$35,700, a sum which is 50 per cent greater than the actual cost of the battery locomotive.

COMMENT BY J. M. DRABELLE[3]

The author has made a valuable contribution to the literature on coal-handling systems, particularly for those who handle Midwestern fuels where spontaneous combustion in the pile is a serious matter. The use of the bulldozer, the carryall, and the tractor means a high compact pile which air cannot enter and, consequently, the hazards of spontaneous combustion are thereby materially reduced.

The use of this type of equipment goes far toward reducing the very high investment charges on the conventional storage systems which have heretofore been used and which also cause a great deal of difficulty due to separation and segregation.

COMMENT BY M. K. DREWRY[4]

The total average coal-handling cost of 37.6 cents per ton, reported in the paper, representing as it does about 10 per cent of the average coal cost, points to the possibility that a little less attention to refinement for station efficiency, and more attention to coal-handling charges, may be warranted. The wide variation in actual coal-handling charges reported suggests that, aside from local factors, important economies in this station service remain to be exploited.

Breakdown emergency coal handling might well be planned as an integral part of the total coal-handling plan so that over-all costs are a minimum. Choice of two half-size independent systems, both operating, may be less expensive in some cases than one efficient full-size system, plus an emergency system of crude design. Because fixed charges are about 3 times operating charges, at least 16-hr operation seems warranted; 24-hr operation of half-size emergency apparatus would supply most emergency needs.

[3] Consulting Engineer, Iowa Electric Light and Power Company, Cedar Rapids, Iowa. Mem. A.S.M.E.

[4] Assistant Chief Engineer of Power Plants, Wisconsin Electric Power Company, Milwaukee, Wis. Mem. A.S.M.E.

Spontaneous combustion in large coal piles, exposed to high and continued winds, cannot always be prevented with certainty by tractor treatment during storage, especially when storage rate and method preclude compacting in thin layers. Covering with an airtight layer of fine coal has the advantage that air leaks are evidenced by vapor discharges and are readily and definitely stopped. Thus, prevention of firing is assured, which is very important in large piles.

The dust-tight coal bin of the author's design is novel and interesting. Coal-dust fire hazard of conveying equipment, a real threat to interruption of service, is an important advantage of this design.

The author deserves commendation for this useful paper. His inclusion of actual operating costs of several systems makes the paper especially valuable.

COMMENT BY A. J. STOCK[5]

The flow of solid materials is not very well understood. Most engineers design bunkers, or downspouts or hoppers beneath them, along lines that would be good hydraulic design. Solid materials follow different laws of flow.

The sharp pyramid-bottom coal bunker that is now receiving so much favor, aggravates the sticking tendencies of the fuel rather than helps the flow. Bunker sides placed at a flatter angle to the horizontal will definitely improve the characteristics of the bunker as far as coal flow characteristics are concerned.

We believe that a study of the laws of flow of granulated materials would prove to be of great benefit to all power-station operators, as well as to engineers in a wide variety of other industries. We have suggested to E. R. Kaiser of the Research Committee of the Fuels Division of the A.S.M.E. that such a research program be undertaken.

We might add to the author's comments, regarding trends in the design of coal-handling equipment, that we have noticed in recent years a decided increase in the size of coal valves. Practically all pulverized-fuel plants today are using 18-in. coal valves. Large stoker installations are using 16-in. valves, and small stoker installations are using 14-in. valves. Numerous central stations are using even larger valves. Several installations of 24-in. valves have been made, and one installation is going in with 30-in. valves. An increase in the valve size has been made necessary because of the greater sticking tendency of the fuel.

A decided trend has been noted toward making the connection between the bunker and stoker or the connection between the bunker and pulverizer absolutely dust-tight. Some installations which we have built have carried this feature to the point of making all equipment in this zone even pressure-tight.

The difficulties experienced with the sticking of fine damp coal in totally enclosed dust-tight systems has developed a demand for some means to indicate whether or not the coal is properly flowing within the various spouts and chutes. Suitable alarm systems are now available.

We disagree with the author's statement to the effect that the "weighing of coal to individual boilers is finding less favor than formerly." Information at hand indicates that this is far from the case. In fact, the majority of central-station boilers are now being equipped with individual coal scales. One reason why individual scales are finding greater favor is because boiler units have become larger and, therefore, the investment in this scale as a percentage of the total project has become smaller; hence the benefits to be derived from the scale are more readily justified. Another reason why individual scales are gaining in favor is that, in recent years, coal scales have been greatly improved in design and they can now be obtained absolutely dust-tight.

Coal scales also present a very satisfactory arrangement for obtaining coal samples. Samples of coal can be taken at the point of discharge from the feed belt of the scale. At this point the coal stream is reduced to a small cross section and, therefore, satisfactorily representative samples can be obtained.

[5] Engineer, Stock Engineering Company, Cleveland, Ohio. Mem. A.S.M.E.

Progress in Railway Mechanical Engineering

TO THE EDITOR:

The report of "Progress in Railway Mechanical Engineering, 1940–1941"[6] represents a most notable addition to railroad literature, upon which the members of the A.S.M.E. may well look with a great deal of pride, since it constitutes a record of much value, not only now, as a mark of current progress, but as a historic document available for future reference.

It is indeed sad to note, however, that this report was compiled by a nonrailroad man, with the co-operation of two individuals, only one of whom is a railroad man. It is more sad to review the personnel of the Executive Committee of

[6] Published in MECHANICAL ENGINEERING for December, 1941, pages 879–892.

the Railroad Division, less than half of whom, not including the present chairman, are railroad men, and to note that of ten past-chairmen of the Railroad Division only two were railroad men.

A number of reasons may be advanced to account for these melancholy statistics, all of which are humiliating to those who are responsible for the operation of railroads in this country. Perhaps the most embarrassing, though not the most obvious, explanation may be that railroad men as a class are not articulate, taking perhaps a somber pride in considering that they deal in *things* rather than with *words*, and are thus content to let others be vocal while they remain modestly in the background, as did Martha of old.

It seems too bad, however you look at it!

Yours very truly,
"R. Roader."

Carnegie's Part

TO THE EDITOR:

Will you allow me to record a historical event which I know to be correct:

When a committee asked Mr. Andrew Carnegie if he would donate funds for a United Engineering Building, including The Engineers' Club, Mr. Carnegie asked, "How much?" He was told $250,000 and once replied, "I am not interested but when you gentlemen find out what a building suitable for the American engineers ought to cost come and see me again."

Later young Mr. Calvin W. Rice called on Mr. Carnegie, who again asked "How much?" Mr. Rice said, $1,000,000.

Mr. Carnegie replied, "I will give you a million dollars."

"But look here, young man, if the building costs seven dollars more than the million I won't kick about the extra seven dollars."

Then Mr. Rice went to Europe (probably Mr. Carnegie suggested the trip), and when he came back he again called on Mr. Carnegie and said, "I think I made a mistake in asking for one million. I think that we need a million and one half." Mr. Carnegie at once replied, "I'll give $1,500,000"—which promise he confirmed in his famous letter of March 14, 1904, which now, cast in bronze, decorates the entrance hall of our Engineering Societies Building.

This was probably the most unconditional gift that Mr. Carnegie ever made and resulted in our two magnificent buildings.

T. KENNARD THOMSON.[7]

[7] Consulting Engineer, New York, N. Y. Life Mem. A.S.M.E.

Aims and Objects of the A.S.M.E.

TO THE EDITOR:

The letter to the editor by Gregory M. Dexter on "Aims and Objects of The American Society of Mechanical Engineers," which appeared in the December, 1941, issue of MECHANICAL ENGINEERING, sort of brings a question to the floor that has been discussed in the "cloakrooms" for many years. I admire Mr. Dexter's courage and the admirable manner in which he has presented his case.

My committee work in the Society has been closely related to the program activities, primarily as secretary of one of the professional divisions. The job of securing authors and papers, especially for the Annual Meeting, has been a function of the professional divisions for many years. Finding authors and persuading them to contribute papers has never been easy. Papers that are contributed without solicitation have always been appreciated. They usually create the most interest and arouse the liveliest discussion.

Once a paper has been received, the next job has been "to get it by" the Standing Committee on Meetings and Program, or often enough, the Standing Committee on Publications. I am familiar with some of the cases which Mr. Dexter has cited, and am entirely agreed with his statements on the situation with respect to the program-building work of the Society.

Referring to the "cloakroom discussions," there has always been a feeling among many of us, especially with papers dealing with economic and professional-status subjects, that the only papers that "could get by" were those that presented "facts" we liked to hear, or those in which the unpleasant things were sufficiently taffy-coated to take the bitter taste away. In some instances, the taffy-coating has resulted in papers so badly involved that no one could understand what the author was talking about. There has always been too much writing and rewriting of controversial papers just to get them through our program-making system.

I have sat in committee meetings where the previews of papers have brought forth more worth-while discussion and information than the actual presentation of the revamped paper accomplished later. Unfortunately, only a comparatively few members of the Society can serve on the several program-making activities. Most of us have to wait until the cheer leader gives the signal after the game is over.

Frankly, I have been wondering if the Society should concern itself with economics and associated subjects as much as it does. We have tended to broaden "engineering economics" until it covers practically everything. Engineers are not economists, and their interests are too selfish for them to think along the broad lines that economists are expected to think. Many of our papers too often bear the earmarks of propaganda, as Mr. Dexter intimates of the paper, "Inland Ocean," by L. K. Sillcox. Few consider The American Society of Mechanical Engineers as being an authoritative source on economic subjects.

If we do continue our present policy with respect to economic subjects, I would like to suggest that we segregate such papers from our technical program, not only with respect to meetings but to committee handling as well.

MARION B. RICHARDSON.[8]

[8] Manager, Engineering Records, Breeze Corporation, Inc., Newark, N. J. Mem. A.S.M.E.

Operating Responsibilities

COMMENT BY J. M. DRABELLE[9]

This paper[10] calls sharply to the attention of all, the delicate piece of machinery called an "operating organization." Many people feel that because things run smoothly the operating men have little or nothing to do and anyone can do that work. Hence the tendency to meddle with such organizations is great.

Such meddling and interference often result in labor trouble. Most labor trouble basically starts from insignificant causes. Small grievances, which for some reason the superior will not face and will not take care of, are permitted to accumulate until they become a serious matter. The sharp-shooting foreman, the tough hard-boiled foreman, and the overly smart timekeeper are fundamentally at the bottom of most labor troubles and most flareups which interfere with smooth-running organizations today.

[9] Consulting Engineer, Iowa Electric Light and Power Company, Cedar Rapids, Iowa. Mem. A.S.M.E.

[10] "Qualifications for Operating Responsibilities," by A. D. Bailey, MECHANICAL ENGINEERING, October, 1941, pp. 719–722.

COMMENT BY LINN HELANDER[11]

In the Student Branch Bulletin of the Society dated March, 1936, George M. Eaton published a paper on "Research as a Life Work." This paper dealt with the qualifications that men who wish to enter the field of industrial research should possess. The present paper on "qualifications for operating responsibilities," and one by W. E. Johnson[12] on "qualifications for design responsibilities," are of a similar character, all three constituting valuable material for teachers and students alike. It is greatly to be desired that sometime in the near future, additional papers will be presented on (1) qualifications for responsibility in sales engineering, (2) in shop production, and (3) in management.

Teachers must take into account more and more the functional branches of engineering in arranging curricula and guiding students. To do so, they must know the qualifications for success in each of the various functional branches.

The problem of training men for operating responsibility is obviously one of molding character. However, character cannot be molded in the desired direction unless there is present at the beginning those elements of character which are to be developed. As the author indicates, the young engineer, who enters the field of operation, should be stable and objective, he should be human, he should have an interest in economics and in the operation of machines, his judgment under stress should be sound, and he should be able to anticipate emergencies and prepare for them so they will not develop.

COMMENT BY J. A. KEETH[13]

This paper gives an admirable "picture," to use the author's own word, of the view any successful operating man should see in retrospect. It should be particularly appealing to operating engineers because, to a very effective degree, it extols a branch of the profession which has all too frequently been looked upon as little more than an occupation. If one looks back to his own college or university class he may be surprised to find how few of his colleagues entered and have stayed with plant-operating work. The answer to this cannot be that there are fewer operating positions; it must be that this type of employment does not appear attractive to the average engineering graduate. This paper should effectively arouse an active interest in this line of engineering.

Certainly, as the author has explained, the qualifications for a successful operating engineer demand as much intellect, basic technical knowledge, and more human understanding than do many design, sales- or research-engineering jobs. Neither should the operating job be looked upon as one involving a monotonous routine. Only a man who, like Mr. Bailey, has spent years in this type of work knows how varied and interesting it can be, or how much on the alert the engineer must be to anticipate and effectively meet the many problems with which he will inevitably be confronted. In the writer's opinion, a good operating engineer must have many of the characteristics of a research engineer. He is certain to be confronted with problems, that are so peculiar to his own plant, that in many cases only by original research on the part of his associates and himself can they be solved. This does not mean that he cannot learn from others, but rather that he must fit the experience of many others into his picture and then supply the parts that are missing, from his own experience and an analysis of local conditions.

It is the writer's conviction that a good operating engineer must have something in his make-up that is not necessarily required in other branches of the profession. One of these qualities is the ability to think quickly and accurately when under pressure of an emergency. The author states that emergencies do not arise in the well-operated power station. What he means by this is that, through the medium of a good operating personnel, so many of these emergencies have been anticipated and provided for that those that do occur are indeed rare. The fact that they do sometimes occur only serves to prove the point that the operating engineer's job is to anticipate and provide means to guard against failures. However, to come back to the point, only the man who can think fast and accurately in the emergency has the proper make-up to be a good operating engineer. He may be ever so well versed in the theory and fundamentals of the equipment he operates; yet, lacking this stability and poise in an emergency, he will be a failure as an operating engineer.

Mr. Bailey has failed, probably intentionally, to mention a problem that the present-day engineering graduate faces if he intends to enter operating work. That is the one which has been brought upon us by the strict seniority clauses of many labor contracts. Certainly no young engineer leaving college wishes to take a job where, regardless of his ability, he knows he will have to await his turn for promotion as dictated by seniority. If he cannot see that his efforts and study are to be rewarded as compared with the man who holds his job solely because of a labor contract and certain federal laws, then he will surely seek some other field of endeavor. However much we dislike to admit this condition, it must be faced squarely and, unless some solution can be found, the operation of our plants will inevitably suffer. In many cases young engineers are engaged on operating jobs as extra men, assuming little or no actual operating responsibility. By such processes we may be able to develop capable supervisory engineers, but it is doubtful whether these men will have acquired the essential experience they would have received couldthey have earned their way to that supervisory position by having assumed the responsibilities and full duties of the lower and intermediate jobs.

With the present system of plant operation, the young engineer must cultivate, more than ever before, the ability to get along with his fellow workers. He must go farther if he is to straighten out this employment maze we are now in. He must possess the ability to lead or redirect the social and political thoughts of his fellow workmen back to the tried and true principles that have shown that honest effort is the best stepping stone to a larger share of the amenities of life. The young operating engineer will find it difficult to obtain information from a fellow employee who has been misguided into the belief that someone is trying to go around him and prevent him from getting that for which he himself is unwilling to put forth the required effort. The young operating engineer must more than ever be a human engineer, directing those mental forces, with which he is placed in contact, to a useful and rational form of thought and living. Today, the path of the young operating engineer is more circumscribed by detours and pitfalls than ever before. Only those, who realize that they can achieve their goal more surely by helping others along the right pathway than by trying to use them as a ladder to lift themselves, can hope to succeed.

These remarks may seem unduly pessimistic and tend to discourage the young engineer from following the operating profession. On the contrary, it is hoped they will be taken by these young men as a challenge to solve the problems effectively, and to make this profession of ours take on a new importance in this modern way of life.

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[11] Professor of Mechanical Engineering, Head of Department, Kansas State College, Manhattan, Kan. Manager A.S.M.E.

[12] "The Functions of the Design Engineer," by W. E. Johnson, MECHANICAL ENGINEERING, May, 1941, pp. 339–342.

[13] Manager of Power Production, Kansas City Power and Light Company, Kansas City, Mo. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of December 12, 1941, subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 945

Revised Item (1) of Reply

(1) The working temperature shall not exceed 400 F.

CASE No. 954

(Interpretation of Par. U-13(b))

Inquiry: There is an inconsistency in Pars. U-13(*a*) and (*b*) with respect to the use of material complying with Specification S-2. Should not the requirements in Par. U-13(*b*) conform with that given in Par. P-2(*c*) which permits the use of material complying with Specification S-2?

Reply: It is the opinion of the Committee that the intent of the last sentence of Par. U-13(*b*) is as follows:

"All such steel shall conform to Specification S-1 except for the tensile limits."

ACTIVE INTERPRETATIONS

The following is a list of active interpretations of the A.S.M.E. Boiler Construction Code as of January 1, 1942:

724	863	905	937
732	864	909	938
753	874	917	939
780	879	920	940
793	880	923	941
808	883	924	942
824	885	925	943
828	890	926	945
830	892	929	946
840	896	931	948
841	897	932	949
842	898	933	950
845	900	934	951
850	901	935	952
855	903	936	953
			954

ERRATA

In the 1940 edition of the Unfired Pressure Vessel Code, there is a typographical error in the first section of Par. U-68(*h*). To make the text of this section identical with that shown in the 1940 addenda, it should read as follows:

"(*h*) Nondestructive Tests. All longitudinal and circumferential welded joints of the structure shall be examined throughout their entire length by the X-ray or the gamma-ray method of radiography."

Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in small capitals; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-22. Insert the following as second sentence of second section:

The maximum allowable working pressures for copper clad tubes used in fire-tube boilers shall be determined by the formula in Table P-4 in which t may be increased by one-half the thickness of the cladding.

Revise present second sentence to read: COPPER TUBES OR COPPER CLAD [such] tubes shall not be used for pressures exceeding 250 lb per sq in., nor for temperatures exceeding 406 F.

PAR. P-112(*a*). Delete the words "but not water wall headers" in first sentence.

PAR. P-299(*d*). Revised first section:

All valves and fittings on all feedwater [piping and water piping below the water line] PIPING BETWEEN THE BOILER PROPER AND THE REQUIRED VALVE OR VALVES shall be equal at least to the requirements of the American Standards for a pressure 25 per cent in excess of the maximum allowable working pressure OF THE BOILER.

PAR. P-299(*e*). Replace the first two sections by the following:

In all cases the scheduled working pressure (primary service pressure rating) for American Standard steel fittings may be adjusted to the actual allowable working pressure according to Table A-9 in the Appendix, except that valves and fittings of steel construction equal to the American Standards given in Table A-6 may be used for maximum saturated steam pressures and for feed and blow-off services not to exceed the adjusted maximum allowable boiler pressure shown in Table P-15.

Specification S-17. Add the following note preceding Par. 1:

(*Note: Tubes for unfired pressure vessels complying with A.S.T.M. Specifications A179-40 will be acceptable as complying with the intent of Specification S-17.*)

PAR. H-38. Add the following as (*b*):

(*b*) A heater for oil or other liquid harmful to boiler operation shall not be installed directly in the steam or water space within a boiler.

Where an external type heater for such service is used, positive means must be provided to prevent the introduction into the boiler of oil or other liquid harmful to boiler operation.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

The Nature of Thermodynamics

THE NATURE OF THERMODYNAMICS. By P. W. Bridgman. Harvard University Press, Cambridge, Mass., 1941. Cloth, $5^3/_8 \times 8^1/_8$ in., 229 pp, 3 figs., $3.50.

REVIEWED BY JOHN E. NISCARDI[1]

IN this book Professor Bridgman attempts to make what he calls an "operational analysis" of thermodynamics. It is an amplification of the remarks on the concepts of energy and thermodynamics contained in his volume on "The Logic of Modern Physics," which was published in 1926. On page 6 of that work, in criticizing Newton's concept of absolute time, the author stated:

> It is evident that if we adopt this point of view toward concepts, namely, that the proper definition of a concept is not in terms of its properties but in terms of actual operations, we need run no danger of having to revise our attitude toward nature. For if experience is always described in terms of experience, there must always be correspondence between experience and our description of it, and we need never be embarrassed, as we were in attempting to find in nature the prototype of Newton's absolute time. Furthermore, if we remember that the operations to which a physical concept are equivalent are actual physical operations, the concepts can be defined only in the range of actual experiment, and are undefined and meaningless in regions as yet untouched by experiment. It follows that strictly speaking we cannot make statements at all about regions as yet untouched, and that when we do make such statements, as we inevitably shall, we are making a conventionalized extrapolation, of the looseness of which we must be fully conscious, and the justification of which is in the experiment of the future.

The preceding prescription would appear salutary on the whole from an engineering standpoint, although it may be doubted whether in the absence of prior acquaintance by direct personal experience it is possible to give meaning to a concept in the operational manner, since in the final analysis the operation consists of comparing a given quantity with a standard quantity of the same kind, so that the operation yields a purely numerical ratio and does not reveal the entity itself. However this may be, it can be surmised that the insistence upon definition of concepts in terms of actual physical operations within the experimental range has proved unpalatable to enthusiastic adventurers in theoretical physics, as evidenced by the fact that in the introduction to the present volume Bridgman practically nullifies his former dictum. This retraction is indirectly accomplished by extending the definition of *operation* to include, besides instrumental operations, not only mental operations but also so-called paper-and-pencil operations, "for," the author asks rhetorically, "are not paper and pencil 'instruments, and is not any 'mental' operation of mathematics thereby reduced to an instrumental operation?" Furthermore, he asserts that in this connection there is no difference between "paper and pencil" and "mathematics" and "verbalizing" in general. In view of all this it is not surprising that the new book contains much "conventionalized extrapolation, of the looseness of which we must be fully conscious."

The initial chapter, comprising half of the entire text, is devoted to the first law of thermodynamics and the closely related concept of energy. Among the subtopics discussed under this head are temperature, some aspects of calorimetry, work and the flow of mechanical energy, frictional heat, internal energy and its functional expression, absolute energy, flux of energy, and the formulation of the first law when a flux of material or of electricity is also involved. It is assumed that the reader has a previous acquaintance with college-grade thermodynamics. The treatment is almost entirely nonmathematical, but, of course, if the subject is to be handled at all the mathematics is then disguised in verbal forms which are likely to mislead the unwary. Thus there is a good deal of talk about posting sentries at every point of the boundary of a thermodynamic system, each equipped with his instrument by which he measures the amount of energy that flows past his element of surface, and then the contributions recorded and reported by each sentry are to be summed up at a central clearing house in order to get the total. Philosophic scientists and scientific philosophers may be expected to discuss this sentry and clearing-house arrangement profoundly in the near future, just as Bridgman himself devotes an appreciable number of pages in this book to Maxwell's famous demon, even going so far as to touch upon the mental endowment of the little chap, the possible details of his trap door, and whether "volition" would be entailed in his activities. Another example of the peculiar operations suggested by the author is the "paper-and-pencil" stratagem for verifying the existence of an equilibrium radiation field in the interior of a body. For this purpose he imagines perfectly reflecting or perfectly absorbing surfaces of zero mass and zero heat capacity. If the reading of a thermometer inside the body remains unchanged no matter how these surfaces are moved about, the conclusion is to be drawn that the existing radiation field has the black-body value corresponding to the absolute temperature of the body. One is left to wonder how surfaces of zero mass could have any properties whatsoever and how such ghostly figments could affect anything.

There is an extensive discussion of the nature of energy, the verbal "compulsions" supposedly inherent in the notions commonly entertained about it, and the inconsistencies arising from certain mental tendencies to look upon energy much as a material thing to which density and velocity can be assigned. Perhaps the most intriguing feature of this section is the inquiry into the feasibility of expressing the flux of mechanical energy through moving elastic solids in terms of a vector product of the stresses and the velocity components by analogy to Poynting's vectorial formulation of electromagnetic flux. In view of the serious doubts concerning the physical validity of Poynting's formula for any except actual radiation fields, the attempted analogy would not seem to be happily conceived; and indeed it results mostly in confusion. For instance, in the simple example of a spring motor accelerating a flywheel through a belt-and-pulley arrangement it leads to the surprising inference that there must be a "negative density" of mechanical energy in order that the formulation may show an energy transfer in the right direction, i.e., from the motor to the

[1] Research Engineer in charge of Physical Testing Laboratory, Plastics Division, Monsanto Chemical Company, Springfield, Mass.

flywheel, whereas the working part of the belt (the taut half) runs at every instant from the flywheel end toward the motor, since the flexible belt can exert only a pull.

The second chapter treats of the second law of thermodynamics. The list of principal topics here is on the whole not unusual, viz., the tendency of isolated systems to approach a "dead level," reversibility and irreversibility, and entropy with its statistical and disorder aspects; but the viewpoint is novel in its repeated emphasis of the meaning of the various concepts in terms of operations and upon the verbalisms involved in common statements and formulations. An unusual section is that on the flow of entropy. As a simple illustration of such flow Bridgman supposes heat to be transferred by a good conducting bridge of relatively small mass between two very large thermal reservoirs which remain at different constant and uniform temperatures, T_{high}, and T_{low}, throughout the process. The bridge having attained a steady thermal state, it then is clear that for any subsequent definite quantity of heat transferred, Q, the hot reservoir suffers a decrease of entropy equal to Q/T_{high}, while the cool reservoir has a simultaneous increase of entropy equal to Q/T_{low}. Since Q/T_{low} is evidently greater numerically than Q/T_{high}, the "universe" has undergone a net increase of entropy, as would be expected. As the bridge is in a thermally steady state, there is no change of entropy therein; but, paradoxically enough, it is precisely in the bridge that the irreversible thermal phenomenon of conduction occurs in view of the conditions postulated for the reservoirs. On the basis of this example Bridgman makes the following remarkable assertion: "It is the generation of entropy that is the result of irreversibility; once generated, entropy may be transported from place to place without necessarily implying any further irreversibility." This looks like a pretty mess of verbalization. If the "generation" of entropy is the result of irreversibility and irreversibility prevails only in the bridge according to the postulated conditions, then it would seem that the entropy must be created in the bridge; and, furthermore, there would have to be produced in the bridge just the right amounts of positive entropy (Q/T_{low}) and of negative entropy (Q/T_{high}) to satisfy the resultant states of the two reservoirs, to which the related entropies would have to be transmitted simultaneously in opposite directions. Besides, it may be inferred that the temperature gradients in the bridge have nothing to do with the transport of entropy, which would therefore resemble radiation in "empty" space inasmuch as it can be transmitted through this bridge medium without making itself evident therein. The situation seems badly tangled, but in all likelihood the author does not intend to have the illustration taken too seriously; it is merely a tentative step in exploring a possible formulation.

The third chapter contains miscellaneous considerations regarding the "universe" of thermodynamic operations, the assumption of matter with special properties, such as an ideal gas or a perfect thermal insulator, the principles of detailed balancing, the paradoxes of the absolute zero, thermodynamics in relation to biological phenomena, and "physical reality." As this review is rather extensive already, none of the many interesting points raised can be discussed here.

The volume closes with a very brief fourth chapter of five pages entitled "Retrospect and Prospect," which sums up the subject in a fashion that is extremely sober in comparison with the provoking exposition that precedes it.

A book of this character is manifestly designed primarily for the theoretical physicist and for those other readers especially interested in the "philosophical" aspects of science. Most practical men are not likely to take kindly to it. Nevertheless, engineers and particularly mechanical engineers concerned with any branch of heat practice will find it a beneficial stimulus to a more critical reacquaintance with the fundamental concepts of thermodynamics. A perusal of it will surely flabbergast anybody who has been in expressed or tacit agreement with Maxwell's high-sounding declaration that thermodynamics is "a science with secure foundations, clear definitions, and distinct boundaries." Of course, the engineer may still insist with some justice that his thermodynamics is not too far from what Maxwell said it is by voluntarily disciplined delimitation of contents, methods, and objectives. Endeavoring to follow the splendid model established by Carnot's cycle, he seeks in theoretic analysis to find the simplest possible means of reaching useful conclusions, always expecting nothing better than a reasonable approximation to the detailed behavior of real systems. The deeper probing and understanding of the "ultimate realities" is left to those who are less harried by practical requirements.

Books Received in Library

√ AIR BASE. By B. T. Guyton. McGraw-Hill Book Co., Inc. (Whittlesey House), New York, N. Y., and London, England, 1941. Cloth, $5^1/_2 \times 8^1/_2$ in., 295 pp., illus., $2.50. In narrative style the author describes the environment and activities of a modern air base from his personal experience. The training of pilots, the how and why of cruises, and the human side of life in the squadrons are some of the topics considered in this picture of air-base life for the layman.

√ BELT CONVEYORS AND BELT ELEVATORS. By F. V. Hetzel and R. K. Albright. Third edition, revised and enlarged. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1941. Cloth, $6 \times 9^1/_2$ in., 439 pp., illus., diagrams, charts, tables, $6. This standard work on belt conveyers and belt elevators explains the principles of these mechanisms in a comprehensive, practical manner. Belt manufacture is covered, driving and supporting equipment is discussed, particular uses for certain types of conveyers are indicated, and reasons are given for the various technical details described.

√ BOULDER CANYON PROJECT FINAL REPORTS. Part IV—Design and Construction. Bulletin 1, general features, 301 pp. Bulletin 2, Boulder Dam, 253 pp. U. S. Department of the Interior, Bureau of Reclamation, Denver, Colorado, 1941. Paper, $6 \times 9^1/_2$ in., illus., diagrams, charts, tables, maps, $2 each; paper, $1.50 each. Continuing the series on the Boulder Canyon project, the present bulletins deal with design and construction work. Bulletin No. 1 presents general descriptive information about the preliminary construction, the power plant, and other appurtenances to the dam, Lake Mead, and the All-American Canal system. Bulletin No. 2 presents detailed data and information regarding the design and construction of the dam itself.

√ CIVIL DEFENSE. By C. W. Glover. Third edition, revised and enlarged. Chemical Publishing Co., Brooklyn, N. Y., 1941. Cloth, $5^1/_2 \times 9$ in., 794 pp., illus., diagrams, charts, tables, $16.50. This practical manual presents, with working drawings, the methods required for adequate protection against aerial attack. The comprehensive nature of the work is indicated by the inclusion of material on bombs and their effects, war gases, camouflage, civilian instruction, training of A.R.P. personnel, and cost estimates (British figures), in addition to the large amount of space devoted to the construction of all types of protective buildings and shelters. There is a bibliography.

√ COLLECTIVE WAGE DETERMINATION. By Z. C. Dickinson. Ronald Press Co., New York, N. Y., 1941. Cloth, $6 \times 8^1/_2$ in., 640 pp., diagrams, charts, tables, $5. Problems and principles in bargaining, arbitration, and legislation are discussed in this general treatment of the question of remuneration of workers. The material is divided into five parts, as follows: survey of the field; factors commonly invoked in collective wage adjustments; wages and industrial fluctuations; wage policies and practices in private collective bargaining; and influences of public policy on wages.

√ ELECTRIC POWER STATIONS, Vol. 1. By T. H. Carr, with a foreword by Sir L. Pearce. D. Van Nostrand Co., New York, N. Y., 1941. Cloth, $5^1/_2 \times 9$ in., 376 pp., illus., diagrams, charts, tables, $7.50. Volume 1 of this work on electric power stations deals mainly with the mechanical-engineering aspects. Topics treated include the circulating-water system, cooling towers, coal and ash handling, the

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

boiler plant, pipe work, and turbines. There is an introductory chapter on design fundamentals, and the construction and layout of buildings are covered. Many sketches and diagrams illustrate the text.

ENGINEERING ELECTRICITY. By R. G. Hudson. Third edition. John Wiley & Sons, Inc., New York, N. Y., 1941. Leather, 5 × 8 in., 284 pp., illus., diagrams, charts, tables, $3. Written primarily for technical students not specializing in electrical engineering, this textbook is designed to provide a course with a broad objective. To this end an outline is presented of the fundamental principles and of the applications of electricity and magnetism most frequently encountered in engineering practice. There is a large section of practice problems with answers.

ENGINEERING TOOLS AND PROCESSES, a Study of Production Technique. By H. C. Hesse. D. Van Nostrand Company, Inc., New York, N. Y., 1941. Cloth, 6 × 9$^1/_2$ in., 627 pp., illus., diagrams, charts, tables, $4.50. Engineering shop processes and practices are covered by this comprehensive text. The first three chapters offer a survey of basic materials, elements, and devices. The text then takes up the usual shop processes and machines for foundry work, wood shop, and machine shop. Succeeding chapters discuss production machinery and processes not ordinarily presented in college laboratories, and illustrate their application to the manufacture of specific parts. A large bibliography and a section of questions and problems are appended.

FIRE ENGINEERING HYDRAULICS. By G. O. Stephenson. Emmott & Co., Ltd., Manchester and London, England, 1941. Paper, 5 × 7$^1/_2$ in., 20 pp., illus., charts, 1s. This little pamphlet contains graphic charts from which can be quickly obtained the discharge from nozzles, the loss of pressure because of friction in hose, and the height and reach of jets. These charts are based on John R. Freeman's experiments.

PERSONNEL MANAGEMENT, Principles, Practices, and Point of View. By W. D. Scott, R. C. Clothier, S. B. Mathewson, and W. R. Spriegel. Third edition, McGraw-Hill Book Co., Inc., New York, N. Y., 1941. Cloth, 6 × 9$^1/_2$ in., 589 pp., illus., diagrams, charts, tables, $4. Completely revised and rearranged, the new edition of this text presents a comprehensive outline of up-to-date principles, practices, and instruments in the important relationships of management, work, and workers. The revision includes a discussion of modern personnel practices and procedures supported by a detailed survey of 231 companies employing more than 1,750,000 workers.

PROTECTIVE AND DECORATIVE COATINGS, Paints, Varnishes, Lacquers and Inks: Vol 1. Raw Materials for Varnishes and Vehicles. By J. J. Mattiello. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1941. Cloth, 6 × 9$^1/_2$ in., 819 pp., illus., diagrams, charts, tables, $5. This volume is the first of three which are intended to form a comprehensive treatise on the paint and varnish industry. The present installment is devoted to the raw materials for varnishes and vehicles. Drying oils, resins, driers, thinners and solvents, natural minerals, and ethers are discussed, each chapter being prepared by one or more specialists. An enormous amount of information upon the sources, properties, and uses of these materials is summarized in this work, and numerous lists of references to original papers are included.

RUNNING AND MAINTENANCE OF MARINE MACHINERY. Institute of Marine Engineers, London, England. Second edition. Engineers Book Shop, New York, N. Y., 1941. Cloth, 7 × 10 in., 164 pp., illus., diagrams, charts, tables, $2.50. A practical work, prepared for junior members of the Institute of Marine Engineers, intended as a guide for those entering upon a seagoing career. Steam reciprocating engines and turbines, boilers, Diesel engines, electrical and refrigerating machinery, pumping arrangements, and steering gears are discussed. A list of books is appended.

SMOKE ABATEMENT. By L. V. Briggs. Old Corner Book Store, Boston, Mass., 1941. Cloth, 6 × 9$^1/_2$ in., 175 pp., illus., tables, $2.50. The efforts made by various cities to establish control of the smoke problem are presented, and the serious effects of smoke on health, plant life, and property are described. A considerable amount of the material consists of quotations and excerpts from many sources. The last chapter indicates briefly what is being done abroad.

STRENGTH OF METALS UNDER COMBINED STRESSES. By M. Gensamer. American Society for Metals, Cleveland, Ohio, 1941. Cloth, 6 × 9$^1/_2$ in., 106 pp., illus., diagrams, charts, tables, $2. A course of lectures presented to members of the American Society for Metals in 1940 is given in this work. The lectures set forth the principles that may be used as guides in predicting the resistance to deformation and relative ductility of metals under complicated conditions of loading, from the results of tests made under controlled and simpler conditions.

TABLE OF NATURAL LOGARITHMS, Vol. 2. Logarithms of the Integers From 50,000 to 100,000. Prepared by the Federal Works Agency, Work Projects Administration for the City of New York, conducted under the sponsorship of and for sale by the National Bureau of Standards, Washington, D. C., 1941. Cloth, 8 × 11 in., 501 pp., tables, $2. The second volume of this useful table continues it for the integers from 50,000 to 100,000. Values are given to sixteen decimal places.

TECHNICAL LETTERING. By E. P. De Garmo and F. Jonassen. The Macmillan Co., New York, N. Y., 1941. Paper, 9 × 11 in., 20 pp., illus., diagrams, charts, $1. A system of inclined, single-stroke, free-hand lettering is presented which agrees essentially with the American Standard Drawing and Drafting Room Practice. The lettering assignments are presented on tracing paper to accustom the student to working on that surface.

TEMPERATURE MEASUREMENT AND CONTROL. By R. L. Weber. Blakiston Company, Philadelphia, Pa., 1941. Cloth, 6 × 9 in., 430 pp., illus., diagrams, charts, tables, $4. This textbook is a revision of a preliminary edition published under the title, "Temperature Measurement." Based upon a course offered to Juniors at Pennsylvania State College, it outlines "an experimental study of the methods of temperature measurement with the theoretical principles necessary for their appreciation, intelligent use and extension."

TESTING AND INSPECTION OF ENGINEERING MATERIALS. By H. E. Davis, G. E. Troxell, and C. T. Wiskocil. Preliminary edition for Engineering Defense Training Courses. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1941. Cloth, 7 × 10 in., 372 pp., illus., diagrams, charts, tables, $3.50. In view of the increasing importance of quality control in production and its dependence upon tests and inspection, it is the aim of the authors to provide in this book a general treatment of the problems of testing, with specific reference to the mechanical testing of engineering materials, and to establish the principles for the inspection of these materials. Methods of conducting common tests, applicable to most ordinary apparatus, are described in the second section of the book.

THEODORE VON KÁRMÁN ANNIVERSARY VOLUME, Contributions to Applied Mechanics and Related Subjects, by the Friends of Theodore von Kármán on his Sixtieth Birthday. Edited and published by California Institute of Technology, Pasadena, Calif., 1941. Cloth, manifold copy, 8$^1/_2$ × 11 in., 357 pp., illus., diagrams, charts, tables, $3.75. Twenty-six papers contributed by outstanding workers in the field of applied mechanics are presented in this volume commemorating the sixtieth birthday of Theodore von Kármán. A brief biographical and appreciatory sketch and a bibliography of von Kármán's published works are included.

THEORY AND APPLICATIONS OF HARMONIC INTEGRALS. By W. V. D. Hodge. University Press, Cambridge, England; The Macmillan Co., New York, N. Y., 1941. Cloth, 5$^1/_2$ × 9 in., 281 pp., tables, $4.50. The subject of this book is the study of certain integrals defined in a type of space, locally that of classical Riemannian geometry, which is of importance in various branches of mathematics. The topics covered in the several chapters are: Riemannian manifolds; integrals and their periods; harmonic integrals; applications to algebraic varieties; and applications to the theory of continuous groups.

THROUGH ENGINEERING EYES, Science Selections From Literature. By A. R. Cullimore, re-edited by F. A. Grammer and J. H. Pitman. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1941. Linen, 5$^1/_2$ × 7$^1/_2$ in., 166 pp., illus., $1. Presented with the aim of "picturing the development of science and engineering," this small volume consists of selections from a variety of books, ancient and modern. They were written by engineers, scientists, poets, essayists, and philosophers, but each is included because it has "a direct bearing on engineering."

TOOL DESIGN. By C. B. Cole. American Technical Society, Chicago, Ill., 1942. Cloth, 5$^1/_2$ × 8$^1/_2$ in., 498 pp., illus., diagrams, charts, tables, $4.50. The fundamental principles of design as applied to tooling for production are presented in this practical volume. The many drawings which supplement the text, in most cases actual tool designs, have been selected to cover a wide field and to illustrate principles that find varied application in design work. Quiz questions accompany each chapter.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

"Engineering Production for Victory"—Keynote of A.S.M.E. Spring Meeting, Houston, Texas, March 23-25, 1942

"ENGINEERING Production for Victory" is the keynote of the program for the Spring Meeting of The American Society of Mechanical Engineers at Houston, Texas, March 23-25, 1942. In spite of the strenuous conditions under which most engineers are now working, many members of the Society are contributing papers of such outstanding excellence as to attract attendance from all over the country, making of this year's Spring Meeting one which will result in increased production in industry.

Houston the "Miracle" City

Texas is growing faster today industrially than perhaps any state in the Union and Houston is leading the way in growth and influence among many of the cities in the United States. Geographically, Texas has an ideal location as a production center for real service in such a conflict as the United States is now engaged since it has direct access on its eastern border to the Atlantic Ocean and is centrally located for shipping goods to the Pacific coast.

Houston has been hailed as the miracle city of the present century. It has become the oil capital of the world. Its industries are the greatest in the South. Its port ranks second to New York in deep-sea tonnage. It is the leading cotton market in the universe, and in 1940 it was first in the Southwest in new construction.

The fight to obtain a seaport is typical of Houston. The work of dredging and digging a channel was started in 1912 and in 1914. The little sluggish stream, connecting Houston with the sea, and once alive with alligators and overhung with oaks and cypress, became a thoroughfare for world commerce, wide and deep enough for the largest of ocean-going vessels. Ships from all nations come to its doors and carry away the products of the Southwest to the far corners of the globe. The completion of the man-made port is generally acknowledged as the turning point in Houston's fortunes.

The ship channel and oil have played the major part in the city's development, but other factors also have contributed heavily in bringing this city success. One of these is its geographical location. It lies in the center of the fertile Texas Gulf Coast area, an area rich in agricultural, livestock, and natural resources. The 200,000 farms in this section have an annual cash income from crops and livestock of approximately $186,000,000, almost one third of the state's total. Here is grown most of the rice in Texas, 40 per cent of the cattle, and much of the cotton. Houston has become the spot cotton market of the world and has shipped as much as 1,000,000 bales in a single season.

The Rice Hotel in Houston, which will be the headquarters for the meeting, is the largest hotel south and west of Chicago. It has unusually fine facilities for a convention of this character and has a capacity that could have handled the 1941 Annual Meeting of the Society which was the largest in its history. There are many other fine hotels within a short walk of the Rice Hotel so that any conditions desired by our members as to price or facilities may be had.

War Department Officers to Give Addresses

The Society is recognizing the importance of this Meeting by holding a special meeting of the Council at Houston on Monday, March 23. There is also a certain informal recognition of its importance through the consent of prominent ordnance officers of the U. S. War Department to be present at the Meeting and speak on subjects of great importance. Brig. Gen. Earl McFarland will be the principal banquet speaker and Lieut. Col. D. J. Martin will deliver an address on the subject of the manufacture of large guns. In this connection it should be noted that the Hughes Tool Company of Houston, one of the leading industries of that city for the last generation, has undertaken the manufacture of large guns. This company has very generously invited the members of the Society to make an inspection trip of the plant on Wednesday morning, March 25. This visit will be limited to the number of guards available adequately to take care of the party and of course it is strictly limited to citizens of the United States.

Safety precautions demand that goggles be provided for all making the visit and it is, therefore, required that the Society provide to the officials of the Hughes Tool Company a list of names, company connections, titles, and addresses of all desiring to make this trip. It will also be necessary for each person registering to make the trip to state whether or not he wears glasses. It is urged, therefore, that everyone interested in making this trip,

Courtesy Houston Chamber of Commerce

AERIAL VIEW OF CENTRAL BUSINESS SECTION OF DOWNTOWN HOUSTON, TEXAS

even though at the moment of reading this statement he may be unable to guarantee his attendance, write promptly to the Society's headquarters and give the necessary information. If your letter is not mailed to New York by March 10, then the information should be addressed to Ernest Hartford at the Rice Hotel, Houston.

After the visit through the Hughes Tool plant, the party will proceed to the Grand Prize Brewery, which is directly across the road from the Hughes Tool Company plant, and after an inspection of that plant a luncheon will be served the party as guests of the Hughes Tool Company.

Divisions and Student Branches to Sponsor Sessions

The following Divisions will provide technical sessions: Petroleum, Management, Heat Transfer, Fuels, Marine Power, and the Committee on War Production.

The annual meeting of the Student Branches in Group VII, otherwise known as the Southwest Group, will be held in conjunction with the Spring Meeting of the Society. The colleges included in this group are the University of Arkansas, Oklahoma A.&M. College, University of Oklahoma, Rice Institute, Southern Methodist University, Texas, A.&M. College of Texas, Texas Technological College, and the University of Texas.

It has been planned also to invite the Student Branches of Tulane University, New Orleans, and Louisiana State University, Baton Rouge, to take part in this meeting.

There will probably be about twenty student papers in a contest for some two hundred dollars in prizes. The student sessions are scheduled to be held on Monday afternoon and Tuesday morning and the prizes will be distributed to the students at the banquet on Tuesday evening. Last year when the A.S.M.E. Spring Meeting was held at Atlanta, Ga., the student meeting added considerably to the importance of the convention both in attendance and in the general program. Many of the student papers compare favorably with those presented at the national meetings of the Society.

Advance Registration

Advance registration is desirable, if not necessary, because of the conditions under which this meeting is being arranged. Obviously no one can say today where he will be next week or next month. All engagements by people of importance are made contingent upon national developments and whereas all of the speakers who are consenting to be present at this meeting feel that they are making a direct and definite contribution to Engineering Production for Victory, they nevertheless must accept contingent upon emergencies which may develop. Therefore, it is desirable that each member of the Society, or his guest, advise the Society if he is interested in attending the meeting. If he is going to the meeting to be present at one or two particular sessions it would be wise to say so, and to name the sessions in the letter that he sends to the Society headquarters at 29 West 39th Street, New York, before March 10, or to the Society at the Rice Hotel, Houston, Texas, if mailed after March 10. Then it may be possible for a notice to be sent, in case one of the speakers in whom he is especially interested finds it necessary to cancel his attendance.

Plant and Other Trips

The trend of the times is against large organized trips to industrial plants even though they may not be engaged directly in the production of war materials. However, the committee in charge of this meeting has been assured that opportunity will be offered for small groups of members personally to be conducted through one of the shipyards near Houston, through a sulphur-manufacturing company, a steam-power station, and a cement plant; to one or two of the important air fields, as well as to other especially interesting activities in and around Houston.

Engineering educators are offered a rare treat in the opportunity to visit at least four important engineering institutions, which are rated among the largest engineering colleges in this country. These include Rice Institute, University of Texas, A.&M. College of Texas, and the University of Houston.

Courtesy Houston Chamber of Commerce

RICE HOTEL, HOUSTON, TEXAS
(Headquarters for A.S.M.E. 1942 Spring Meeting.)

Women Are Especially Invited

Women are especially invited to attend this meeting not only because of the opportunity afforded to enjoy "June weather" in March but because of the many attractions of a scenic, historic, and educational character offered by this section of Texas. Arrangements will be made for visits to Galveston and to the San Jacinto battlefield and the very unusual monument which marks this historic spot. This glistening shaft rises 567 feet above the hallowed soil, 12 feet loftier than the Washington Monument. On the apex of this shaft is a huge star 35 feet high and as many feet in breadth, weighing 220 tons. The foundation of this memorial has been built to last for centuries. A view of this monument appears on the cover of this issue of Mechanical Engineering. On this historic battlefield is also to be found the celebrated San Jacinto Inn where a seafood meal unsurpassed may be enjoyed. Here is one of the few remaining places where no limit is placed either on the size of the portion or the number of portions served.

Entertainment events which have been arranged especially for the women include the Banquet. An attractive arrangement has been made with the Rice Hotel whereby those wishing to enjoy dancing and other entertainment will be given tickets (obviating cover charges) to the Empire Room in the hotel where an excellent floor show may be enjoyed and where the music will be furnished by a well-known orchestra. A style show on Tuesday afternoon in the Empire Room of the Hotel will undoubtedly be another attraction.

Tuesday Luncheon

The Tuesday luncheon will be held jointly with the Houston Engineers' Club, a large inclusive engineering organization which regularly turns out 125 to 175 members at its semimonthly luncheon meetings. This will give A.S.M.E. members generally, and visiting members particularly, an opportunity to meet and talk with many of the engineers of Houston and vicinity.

Let Us Know

Negotiations are being conducted with other prominent speakers, other than those mentioned in our program, who are unwilling to have their names mentioned until there is some certainty of their ability to be in Houston at the time of our meeting. Headline speakers on the program to speed War Production for Victory include Dr. E. L. DeGolyer, Director of Conservation, Office of

Petroleum Co-Ordinator for National Defense, Washington, D. C., who is also a John Fritz Medalist and Past-President of the A.I.M.E., our own President, James W. Parker, Col. W. B. Tuttle of San Antonio, and Col. James L. Walsh, Chairman of the A.S.M.E. Committee on War Production.

A general announcement of the Spring Meeting will be distributed to all those members within a radius of 1500 miles of Houston and to any others beyond that radius who request Society headquarters for these notices. You are urged to make your plans immediately to be at this fine Texas meeting and to advise A.S.M.E. headquarters so that you may be kept informed of progress. A more detailed outline of the program is given on the following page.

Aviation in Texas Takes a Bow at the Houston Meeting

Well-Known Leaders in the Field of Aeronautics on Program of Aviation Sessions

ONE of the special features of the Houston meeting will be two aviation sessions with nationally prominent speakers, two inspection trips to aeronautical centers in and near Houston, and probably an aviation dinner.

Texas the Training Ground for the U. S. Air Corps

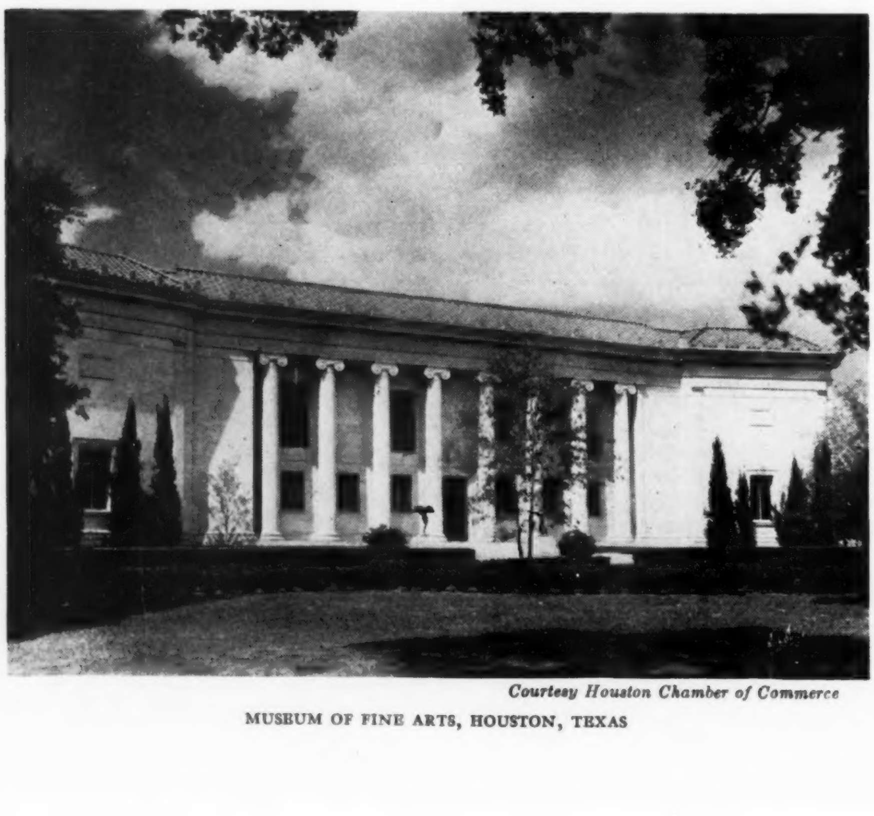
This feature of the program is especially timely in view of the recent expansion of aeronautical developments in Texas and the increasingly prominent part this section of the country will play in the nation's aviation business. This expansion has been along manufacturing, military, civil aeronautics, transportation, and educational lines. The new manufacturing developments of North American and other aviation companies around Dallas and Fort Worth together with the established aviation activities around the neighboring city, Tulsa, is merely the beginning of a sound growth which on account of its location is destined to continue to progress. In the military field, Texas is usually referred to as the training ground for the United States Army Air Corps.

The state is also served by many local and national air lines. The Civil Aeronautics Administration among other activities in Texas has established a large standardization station in Houston.

In the line of higher education, the state has recently added aeronautical engineering to the curricula at the Agricultural and Mechanical College at College Station and the University of Texas at Austin. These courses are now in charge of nationally known educators.

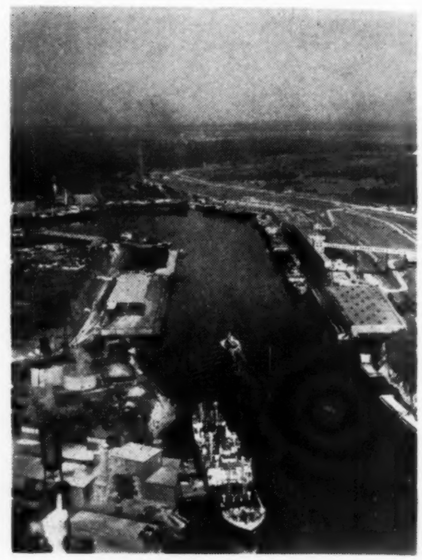
Atwood to Talk on Expansion of Aircraft Production

On the program of the aviation sessions will be J. L. Atwood, vice-president and general manager of North American Aviation, Inc., who will speak on the expansion of aircraft production appropriate to the occasion. Mr. Atwood is a native Texan, a graduate of the University of Texas, and much interested in the aviation developments of this section of the country.



Courtesy Houston Chamber of Commerce

MUSEUM OF FINE ARTS, HOUSTON, TEXAS



Courtesy Houston Chamber of Commerce

HOUSTON SHIP CHANNEL

(At a cost of about $23,000,000 Buffalo Bayou has been transformed into a deep waterway and an ocean port created. From the Turning Basin, within the city, to the Gulf of Mexico, the Channel is approximately fifty miles long, with a depth of 30 ft and a minimum bottom channel width of 150 ft.)

Jerome Lederer, who is the director of the Safety Bureau of the Civil Aeronautics Board, will discuss the use of motion pictures in accident analyses, and will show samples of pictures made in connection with his work. Bennet H. Griffin, Director of the Standardization Center, Civil Aeronautics Administration at Houston, will discuss the work of his organization in keeping ahead of aviation development.

Dr. John E. Younger, the national chairman of the Aviation Division of The American Society of Mechanical Engineers, and recent recipient of the Spirit of St. Louis Gold Medal "for meritorious service in the advancement of aeronautics" particularly in the technical development of metal construction and the stratosphere airplane, will speak on the subject of building tomorrow's airplanes today.

Prof. H. W. Barlow, head of department of aeronautical engineering, A.&M. College of Texas, will present and illustrate a review of the development of aviation activities in Texas.

Dr. M. J. Thompson, who is graduate professor of aeronautics at the University of Texas, will also take part in the programs. Prof. R. M. Pinkerton of the University of Texas will give a talk on the research laboratories of the National Advisory Committee for Aeronautics and will show moving pictures of the activities of these laboratories.

Arrangements are being made also to obtain speakers from the manufacturing field around Dallas and Fort Worth, from the military aviation centers, and from the educational institutions.

A.S.M.E. Spring Meeting Program

Houston, Texas, March 23–25

Headquarters, Rice Hotel

MONDAY, MARCH 23

9:30 a.m. Council Meeting
Registration

12:15 p.m.

Lunch: Council, Committees, and Authors

2:00 p.m.

Fuels—I

Design, Installation, and Operation of Domestic Gas-Fired Floor Furnaces, by Robert Reed
Natural Gas—Production, Distribution, and Utilization, by W. B. Poor

Petroleum—I

The Operating Characteristics of Fluid-Actuated Pumps, by C. M. Rader and R. G. Ralph
Pumping Equipment for Oil-Well Cementing, by W. D. Owsley
Talking Motion Picture—Hughes Industrial Sound and Color Rock Bit Film, by F. L. Scott

Student Session—I

Contest for cash prizes as part of the regular Annual Southwest Student member's meeting

Textile

Textile Engineering and What It Means to the Southwest, by J. B. Bagley
The Mechanical Harvesting of Cotton as Influenced by Varietal Characteristics, by H. P. Smith and D. T. Killough

6:30 p.m.

Authors' Dinner

8:00 p.m.

Marine Power

Marine Boilers, by T. C. Stillman
Effect of Valve-Seat Deflection, by Harte Cooke

Petroleum—II

Redesigning of Field Tank Batteries for Conservation Purposes, by R. M. Stuntz
Petroleum Conservation in the War Effort, E. L. DeGolyer

Corrosion

Protection of Buried Metals Against Corrosion, by Starr Thayer
The Application of Cathodic Protection for Corrosion Prevention, by R. J. Sullivan

War Production

Development Work of the Ordnance Laboratory at Frankford Arsenal, by John A. Bailey
Manufacture of Large Guns, by D. J. Martin
Discussion Leader: W. M. Sheehan

TUESDAY, MARCH 24

9:00 a.m.

Training Labor for Production

New Responsibilities for Labor, by H. W. Acreman, J. R. Steelman, and T. M. Davis

Shell and Tube Heat Exchangers

(Auspices Heat Transfer Division)

A Review of Heat-Transfer Coefficients and Friction Factors for Tubular Heat Exchangers, by B. E. Short
Condensation of Saturated Freon-12 Vapor on a Vertical Bank of Horizontal Tubes, by W. J. Wohlenberg and F. L. Young, Jr.
Heat Transfer, Pressure Drop, and Fouling Rates of Liquids for Continuous and Noncontinuous Longitudinal Fins, by A. Y. Gunter and W. A. Shaw

Aviation—I

Development of Aviation in Texas, by H. W. Barlow
Keeping Ahead of Aviation Development, by Bennet H. Griffin
Résumé of Activities of Research Laboratories of the National Advisory Committee for Aeronautics, by R. M. Pinkerton

Student Session—II

12:15 p.m.

Lunch with Houston Engineers Club
Talks by W. B. Tuttle and James W. Parker

2:00 p.m.

Small-Plant Management

Priorities for the Small Manufacturer, by G. L. Noble

Heat-Recovery Equipment and Flash-Freezing Foods

Operation and Maintenance of Air Preheaters, by Joseph Waitkus
Construction of Water-Cooled Furnaces, by Max Kuhner
Quick and Flash-Freezing of Foods: The Fundamental Theories and Applications, by W. R. Woolrich and L. H. Bartlett

Fuels—II

Round-Table Discussion on Trouble Shooting on Gas and Oil Burners
Chairman: Carl J Eckhardt
Contributors: E. L. Dennis, R. C. Vroom, L. S. Reagan, and C. L. Orr

TUESDAY, MARCH, 24 *(Continued)*

2:00 p.m.

Petroleum—III

The Metering of Petroleum Products as a Measure of National Defense, by L. R. Van Arsdale
Automatic Control of Natural Gas Fuel Power Boilers, by Charles W. Parsons

Aviation—II

Building Tomorrow's Airplanes Today, by J. E. Younger
Motion Pictures in Accident Analysis, by Jerome Lederer

6:30 p.m.

Banquet, Dancing, and Entertainment
Speaker: Brig. Gen. Earl McFarland

WEDNESDAY, MARCH 25

9:00 a.m.

Trip to
Hughes Tool Company and Grand Prize Brewery
Cement Plant
Sulphur Plant
Power Station

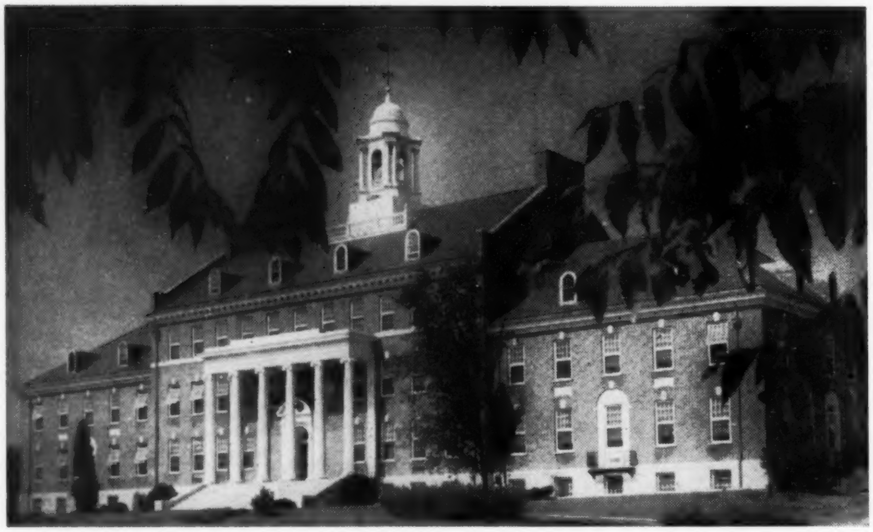
12:15 p.m.

Lunch at Hughes Tool Co.

Registration Fee for Nonmembers at the 1942 Spring Meeting

There will be a registration fee of $2 for nonmembers attending the 1942 A.S.M.E. Spring Meeting at Houston, Texas, March 23-25, 1942. For nonmembers wishing to attend just one session of the meeting the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Society before March 16, 1942, asking for a guest-attendance card for the Spring Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.



ENGINEERING BUILDING, UNIVERSITY OF MARYLAND, NEW NATIONAL HEADQUARTERS OF A.S.M.E. AVIATION DIVISION

A.S.M.E. Aviation Division National Headquarters Moved to University of Maryland Campus

John E. Younger to Be Permanent Secretary

THE Aviation Division National Headquarters of The American Society of Mechanical Engineers has been moved to the University of Maryland and John E. Younger has been designated permanent secretary of the Division. Dr. Younger will fill this office on a part-time basis in conjunction with his regular duties with the University as professor and chairman of the department of mechanical engineering.

Dr. Younger is one of the pioneers in aeronautical development in this country and has a host of friends and professional contacts in the industry throughout the country.

JOHN E. YOUNGER AT HIS DESK

The University of Maryland is strategically located for this activity, being in the suburbs of Washington, D. C., and only an hour's flight from New York.

The purpose of this move is to render greater professional service to the more than 2000 members of the Aviation Division. A program for increasing this service is now being studied by the Executive Committee of the Aviation Division under the chairmanship of Dr. Younger.

Have You Received Your A.S.M.E. Membership List for 1942?

A COPY of the new Membership List has been sent to all members of the A.S.M.E. entitled to receive publications. Anyone failing to receive his copy should advise the headquarters office prior to April 20 in order to obtain one without charge. The charge for copies furnished after that date, or for extra copies, will be $1.50 each.

F. E. Giesecke Honored by A.S.H.&V.E.

FREDERICK ERNST GIESECKE, member A.S.M.E., professor-emeritus, A.&M. College of Texas, College Station, Texas, has received the F. Paul Anderson Gold Medal awarded by the American Society of Heating and Ventilating Engineers for distinguished scientific achievement. Presentation was made by Thornton Lewis of Newtown, Pa., donor of the medal, at the 48th annual meeting of the society held in The Bellevue-Stratford Hotel, Philadelphia, Jan. 28, 1942.

Consulting Engineers Elect Officers

AT a meeting of the Council of the American Institute of Consulting Engineers, held in New York on January 20, 1942, Malcolm Pirnie was elected president, R. E. Bakenhus, vice-president, James Forgie, treasurer, and Philip W. Henry, secretary.

Actions of A.S.M.E. Executive Committee

At Meeting in Society Headquarters on January 21

THE Executive Committee of the Council of The American Society of Mechanical Engineers met at the Society's headquarters on Wednesday, Jan. 21, 1942. James W. Parker, President of the Society, presided, and there were also present Clarke Freeman, vice-chairman, Clair B. Peck, G. E. Hulse, G. L. Knight (Finance), G. B. Karelitz (Professional Divisions), J. N. Landis (Local Sections), C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary. At the afternoon session there were also present on invitation members of the Committee on Meetings and Program, as follows: A. L. Kimball, chairman, N. E. Funk, F. G. Switzer, R. A. North, and R. A. Robertson, junior adviser, and Col. J. L. Walsh, chairman of the National Defense Committee. The following actions were of general interest.

Addition to Budget of Professional Divisions

Upon recommendation of the Committee on Professional Divisions and the Finance Committee, an additional appropriation of $4000 was granted for the current year for special assistance for the Aviation Division. It was reported that an agreement had been entered into with the University of Maryland whereby Prof. J. E. Younger, of the mechanical engineering department of the University and 1941 Spirit of St. Louis medalist, would devote a portion of his time to the Aviation Division.

Committee on Registration

The Committee on Registration was established as a special committee, permanent in character, with a personnel to be appointed each year.

Committee on Engineering Organizations Within States

Messrs. H. L. Eggleston, F. H. Prouty, and W. R. Woolrich were appointed to serve on the Committee on Engineering Organizations Within States.

Greetings From Canada and Cuba

The Secretary reported the receipt of communications from The Engineering Institute of Canada extending greetings to the Society and from the Cuban Society of Engineers conveying a message of greeting and good will from the engineers of Cuba.

Defense Committee Name Changed

At the afternoon session the name of the Committee on National Defense was changed to Committee on War Production.

Upon recommendation of the Committee on Meetings and Program, it was voted to continue the present policy of holding four national meetings per year.

K. M. Irwin Named Vice-President A.S.M.E.

K. M. IRWIN, assistant to the vice-president in charge of engineering, Philadelphia Electric Company, has been chosen by letter ballot of the Council as vice-president of The American Society of Mechanical Engineers to fill the unexpired term of W. H. Winterrowd, deceased.

Mr. Irwin has been active in the work of the

K. M. IRWIN

Society over a period of many years. He was chairman of the Fuels Division, 1934–1936; member of the regular Nominating Committee, 1934; chairman of the Finance Committee, 1937–1939; chairman of the Philadelphia Section, 1930–1931; and vice-president of the Society, 1939–1941.

Cuban Engineers Greet A.S.M.E.

WITH the entry of the United States into the war a message of greeting and good will from the engineers of Cuba was received by The American Society of Mechanical Engineers. At its meeting on January 21 the Executive Committee of the A.S.M.E. Council took official notice of the Cuban greetings and instructed the Secretary to reply. The letters follow:

President
The American Society of Mechanical Engineers
33 West 39th Street New York, N. Y.

Dear President:

As President of this Society I wish to express my deepest sympathy to the engineers of your Society, citizens of the United States now in war with Japan and assure them that my country will take action as required by their side, affording us Cuban engineers the opportunity to play our part in war and defense.

This letter is a heart message from the Cuban engineers, members of Sociedad Cubana de Ingenieros to their brethren, the members of The American Society of Mechanical Engineers. We are a small group in comparison with your great Society but we are anxious to help and no other such group anywhere can boast of a more sincere desire.

Cordially yours,

(*Signed*) Ing. Jose Garcia Montes
President

Ing. Jose Garcia Montes, President
Sociedad Cubana de Ingenieros
Havana, Cuba

My Dear Sir:

The Council, at its meeting on January 21st, received and read with pleasure and gratification your communication of December 8th, conveying a message of greeting and good will from the engineers of your country to the engineers of this country and offering co-operation in the international crisis.

The Council has asked that I transmit to you our thanks and good wishes and express to you the sincere feeling of good will of the officers and members of this Society to the officers and members of the Cuban Society of Engineers.

Cordially yours,

(*Signed*) C. E. Davies
Secretary

Midwest Power Conference to Meet in Chicago, April 9 and 10

THE 1942 Midwest Power Conference will be held on April 9-10 at the Palmer House, Chicago. This Conference is sponsored by the Illinois Institute of Technology with the co-operation of the nine other Midwestern universities and colleges and the local sections of the Founder and other engineering societies.

The preliminary program of the Conference will contain, in addition to the opening meeting, sessions on electric power transmission, industrial power plants, hydro power, boilers and stokers, Diesel power, and central-station practice. The latter is sponsored by the Chicago Section of the A.S.M.E. and all arrangements for it are being made by the section's chairman of its Power and Fuels Division, J. R. Michel. In addition to these sessions, the Conference program will include two joint luncheons, one with the Chicago Section of the A.S.M.E. and the other with the Chicago Section of the A.I.E.E. A high light of the Conference will be its All-Engineers Dinner on the evening of April 9.

The Conference will be opened by President H. T. Heald, of the Illinois Institute of Technology, and Dr. A. A. Potter, dean of engineering of Purdue University. Among the papers and speakers of the Conference program are the following:

"Power and the War Effort," by Leland Olds, chairman, Federal Power Commission, Washington, D. C.

Experience With Priorities for Equipment and Maintenance

"Construction and Erection of the New High-Pressure Unit of the Montaup Electric Co.," by F. H. Rosencrants, Mem. A.S.M.E., vice-president, Combustion Engineering Company, Inc., New York, N. Y.

"Maximum Output From Existing Power Plants," by E. G. Bailey, Mem. A.S.M.E., vice-president, The Babcock and Wilcox Company, New York, N. Y.

"Recent Field Experience With Natural Lightning," by Chas. F. Wagner, manager, Central Station Engineering, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

"Lightning Proof Line Design," by A. C. Monteith, manager, Industry Engineering, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

"Power in the Flour Milling Industry," by A. R. Ulstrom, engineer, Cereal Engineering and Construction Company, Minneapolis, Minn.

"Feedwater Treatment in Small Power Plants," by Everett P. Partridge, director of research, Hall Laboratories, Inc., Pittsburgh, Pa.

"Power Recovery Installation as Developed by Buick Motor Division, General Motors Corporation," Melrose Park, Ill., by C. A. Chayne, chief engineer, Buick Motor Division, G.M.C., Flint, Mich.

"Silting of Water Power Reservoir," by E. W. Lane, professor of hydraulic engineering, The State University of Iowa, Ames, Iowa

"Results Obtained by Spreader Stokers With Continuous Ash Discharge"

"Steam Boiler Circulation," by A. A. Markson, Mem. A.S.M.E., research associate, Consolidated Edison Company of New York, New York, N. Y.

"Radial Diesels," by E. T. Vincent, Mem. A.S.M.E., professor of mechanical engineering, University of Michigan, Ann Arbor, Mich.

"Diesel Vs. Steam Locomotives," by Robert Aldag, Jr., member of engineering staff, Chicago, Burlington and Quincy Railroad Co.

National Roster Collecting Data on Men of Draft Age

AT present the National Roster of Scientific and Specialized Personnel is engaged in a collection of special information about persons registered with it whose age would make them subject to call for training and service under the provisions of the Selective Training and Service Act of 1940. Although the Roster has no direct authority with reference to classification or induction procedures under the Selective Service System, it is charged with the obligation of assisting the nation in using the trained personnel in the most effective way possible. Accordingly, under a co-operative plan, the Roster in certain cases will transmit to the office of the National Headquarters of the Selective Service System in Washington, D. C., appropriate information about technically trained persons of military age, and that office in turn may send letters about these men to their local boards, to assist in the determination of their proper classification. Of course, it should be understood that the matter of classification and induction is within the jurisdiction of the Selective Service local boards.

Also, whenever a man registered with the

National Roster is likely to be inducted into the Army, information is sent to the appropriate division of the War Department, on his educational training, occupational experience, and other pertinent data. Obviously, no guarantee can be given in advance that this procedure will result in any special privilege, since there are occupational shortage problems within the Army as well as personality factors that must be taken into account. But the information that has been sent to the War Department about various men has been of very practical use in the procedure of assigning such technically trained individuals to their duties.

4000-Card Index for Use in Chemical Analysis by X-Ray Diffraction

A 4000-card file index of X-ray diffraction data for use in the Hanawalt method of chemical analysis by X-ray diffraction has recently been published by the American Society for Testing Materials. This compilation is sponsored by a joint committee of the A.S.T.M. and National Research Council, under the chairmanship of Prof. Wheeler P. Davey, Pennsylvania State College. The data include not only Hanawalt's original published data, with his later corrections, but also additional data that have been contributed by the Aluminum Co. of America, The New Jersey Zinc Co., together with data taken from the technical literature in the English language.

The cards give all pertinent data found in the sources with provision for insertion of accessory data such as crystal structure, density, etc. The index identifies the three strongest lines in X-ray diffraction pattern of some 1300 crystalline compounds, the chemical names and symbols of which are as given by the various sources.

The Hanawalt method has been described in the technical literature and an A.S.T.M. Committee is perfecting a tentative recommended practice for the identification of crystalline materials by the X-ray diffraction method, with early publication anticipated.

Copies of this 4000-card index packed in finished container boxes can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa., at $50 per set.

Blackouts

THE United States Office of Civilian Defense, Washington, D. C., has issued a 60-page booklet entitled "Blackouts," prepared by the War Department with the assistance and advice of other federal agencies.

From the statement of purpose and scope of this booklet the following is quoted:

"The purpose of this pamphlet is to provide a common basis for instruction, by local civilian defense organizations, in the proper procedures necessary to achieve effective blackouts. A representative selection, covering the entire field of means and methods which have worked in practice, has been made and is presented in this pamphlet. The information furnished and methods outlined are by no means applicable to every type of dwelling, factory, or place of business. In urban and industrial communities the more elaborate blackout procedures will be required, while in farming areas and isolated communities only the relatively simple precautions will be necessary. The choice of means and methods will rest with the responsible individual, subject to the direction of local civilian-defense authority."

The subject matter included covers the information which the civilian population, both as individuals and organizations, needs to know about blackouts.

Separate chapters provide information for those concerned with blackouts of the following types of facilities: Private homes and similar buildings; plants and factories; municipal utilities and large private lighting systems; and the various forms of transportation and traffic control.

Industrial Conservation Plan Devised by Saw Manufacturer

A "Conservation Control Plan" of wide scope designed to save vital materials and to speed up production has been announced by Henry Disston & Sons, Inc., of Philadelphia, Pa. By means of instruction cards called "Conservation Control Cards," the individual worker is told how to handle a particular tool, how to use it efficiently, how to keep it from breaking, how to sharpen it, and other important information which will mean easier and better work for him. There are 35 of these cards, covering cutting tools for metal, wood, plastics, etc., including tool bits, files, hacksaw blades, carboloy knives and cutters, circular metal and wood-cutting saws, band saws for wood or metal, planer knives, etc.

These control cards are supplied free by Disston to any plant, along with buttons bearing a seal and the slogan "Conservation Serves Everyone." In addition, there are posters prepared for the use of plants generally which "sell" the idea to the men as a means whereby their work will be made easier and better. Emphasis is put upon the importance of saving materials in order to make more materials available during this time of emergency and shortages.

Disston is prepared to supply cards, posters, buttons, etc., entirely without cost; nor is it necessary to be a Disston-product user to participate in this important national program.

Management Fellowships

MASSACHUSETTS Institute of Technology announces a fifth nation-wide competition for fellowships in business administration and economics, under grants of funds by the Alfred P. Sloan Foundation, Inc.

Applicants must be between 28 and 35 years of age, citizens of the United States, currently employed but with a year's leave of absence.

Application blanks which can be obtained from W. P. Fiske at M.I.T., Cambridge, Mass., must be postmarked not later than March 17, 1942.

A.S.M.E. Local Sections

Coming Meetings

Anthracite-Lehigh Valley. March 27. This meeting will be held at Wilkes Barre, Pa. Subject: "Nylon."

Central Indiana. March 13. Purdue University, Lafayette, Ind. Joint Dinner Meeting with Student Branch. Talks to be given by two students from Purdue and two from Rose Polytechnic Institute.

Central Pennsylvania. March 24. Joint Meeting with local chapter of S.P.E.E. at State College, Pa. Subject: "Teaching With Animated Cartoons," by Charles E. Gus, executive secretary, College of Engineering, New York University.

Detroit. March 3. Horace H. Rackham Memorial Building, Detroit, Mich. at 8:00 p.m. Subject: "Superpowered Aircraft Engines," by Ralph N. DuBois, executive engineer, Packard Motor Car Company.

New Haven. March 17. Mason Laboratory, Yale University. Subject: "Welding of Aluminum." Speaker: J. K. Wareham, of Aluminum Company of America. Joint meeting with American Welding Society.

St. Joseph Valley. March 17. Joint Meeting with the Student Branch at Notre Dame University. The Student Branch will be in charge of this meeting.

St. Louis. March 27. This will be a dinner meeting. Subject: "Engineering and Trade Problems in Latin America." Speaker: Albert Vigne, president of Bronze Alloys Company.

Washington. D. C. March 12. Potomac Electric Power Company Auditorium, 10th and E Sts., N. W., Washington, D. C. Subject: "Some Properties and Uses of Explosives," by Wilbert J. Huff.

A.S.M.E. Calendar

of Coming Meetings

March 23–25, 1942
Spring Meeting
Houston, Texas

June 8–11, 1942
Semi-Annual Meeting
Cleveland, Ohio

June 17–19, 1942
Oil and Gas Power Division
Peoria, Ill.

October 12–14, 1942
Fall Meeting
Rochester, N. Y.

Nov. 30–Dec. 4, 1942
Annual Meeting
New York, N. Y.

(For coming meetings of other organizations see page 32 of the advertising section of this issue)

Among the Local Sections

Emergency Production of Ordnance, Subject at Akron-Canton

THE Jan. 8 meeting of the Akron-Canton Section, attended by more than 50 members and guests, heard James J. Hopkins, consulting engineer with Hopkins and Kendall, of Alliance, Ohio, speak on the subject, "Experience in Emergency Production of Ordnance." The speaker was well qualified to present this topic, having done extensive full-time consulting engineering work in the manufacture of ordnance material, specializing in electric melting, heavy forging, rough machining, and heat-treating. He discussed the many interesting problems, and their solutions, arising in the manufacture of gun parts.

National Defense Training Starred at Anthracite-Lehigh Valley

"National Defense Training by Colleges and Industries" was the evening's subject at the Jan. 23 meeting of the Anthracite-Lehigh Valley Section. Prof. Fred Larkin, chairman of the mechanical-engineering department at Lehigh University, clearly presented the engineering training program and spoke of the various groups to be found in any industrial organization as well as of the selection and training of the personnel in these groups. Prof. Paul B. Eaton then discussed the educational program, being conducted by Anthracite-Lehigh Valley Section to train defense workers, following which the audience participated in open discussion.

Incendiary Bombs Dealt With at Baltimore Meeting

Sixty-six members and guests learned about incendiary bombs at the Jan. 26 meeting of the Baltimore Section. J. H. Purdy opened his address with a description of the four types of incendiaries, their military use, and methods of dealing with them. The speaker then proceeded to outline the A.R.P. organization for bomb fighting as set up for industrial plants. The latter proved a complicated matter involving consideration of size of plant, kind, and location of equipment, besides personnel training.

Boilers, Topic of January Session of Birmingham

John Van Brunt, at the Jan. 29 meeting of the Birmingham Section, told more than 45 members and guests of design fundamentals in high-pressure boilers. His talk, attractively illustrated with many slides, concluded with a brief discourse on water circulation in the boiler system.

Talk on Product Engineering at Bridgeport

An eager gathering of over 75 members and guests at the Jan. 23 meeting of the Bridgeport Section heard Prof. Earle Buckingham, of Massachusetts Institute of Technology, speak upon the little publicized, but vastly important subject, "Preparation for Product Engineering." Though this subject has proved of vital importance to industry, no one has yet created a setup which would give it necessary professional prominence. The speaker said, "Preparation for production is the present bottleneck in our all-out production schedule. If it is handled effectively, even with small competent forces now available, much can be done. But if zeal is substituted for ability most of the preparation must be done over again. . . Production is mechanized today . . . . . for every type of specialist needed in our armed forces, there are at least ten types of specialists needed in industry . . . Preparation for production as a definite technique has received little . . . attention in . . . production plants. . . It requires as extensive and intensive staff work, meticulous attention to every detail, careful scheduling and timing, rigid adherence to adopted plans, and all-out efforts of every person involved, as any military maneuver." So challenging did this topic prove, that the suggestion is made for other sections to contact the speaker.

Central Illinois Breaks Record With 460 at Meeting

Col. Donald Armstrong addressed more than 460 members and guests at the Jan. 16 meeting of the Central Illinois Section. Col. Armstrong is Deputy District Chief of the Chicago Ordnance District and has been an active Army man for over 32 years, serving in World War I as major of Coast Artillery and later as assistant military attaché at the American Embassy in Paris. He also served two years in Watertown Arsenal and four years as chief of maintenance division in the Office of Chief of Ordnance, Washington, D. C. In his speech, "U. S. Army Ordnance and Matériel," Col. Armstrong made particular reference to the present and future contributions of Peoria's industries to the war program. Through the presentation of various types of ordnance matériel, many manufacturers gained insight into the potentialities of their own plant in producing sorely needed ordnance items in our defense effort.

Plastics Evaluated for Central Indiana Engineers

At the Jan. 9 meeting of the Central Indiana Section, members and guests heard Harry McGowan, of the Bakelite Corporation, describe in detail advantages and disadvantages of each of the plastics. He gave his opinion, after careful survey of the field, as to which compounds would be available in the next year. His very interesting talk was attested to by the hour-long question period following his remarks.

Traffic and Maintenance in Defense Effort Discussed at Chicago

At the Jan. 6 meeting of the Chicago Section, Col. James L. Walsh discussed two important

OFFICIALS OF THE AMERICAN CAR AND FOUNDRY COMPANY AND MEMBERS AND OFFICERS OF A.S.M.E. ANTHRACITE-LEHIGH VALLEY SECTION AT THE SPEAKERS' TABLE IN A DINNER SESSION AT THE BERWICK ELKS' CLUB, BERWICK, PA., ON NOV. 28, 1941, WHEN F. A. STEVENSON TALKED ON "ARMY TANKS"

(Left to right: J. W. Steinmeyer, metallurgical engineer, A.C.F. and past-chairman of the Section; R. H. Porter, chairman of programs for the Section; Harte Cooke, Fellow and Past Vice-President, A.S.M.E.; Prof. P. B. Eaton, member of Council, A.S.M.E.; Walter Tallgren, chairman of the Section; C. H. Folmsbee, secretary of the Section; F. A. Stevenson, senior vice-president, Guy C. Beishline, district manager, H. B. Ensign, manager of ordnance, W. L. Stancliffe, manager of miscellaneous sales, all of the American Car and Foundry Company; Lieut. H. P. Klair; H. O. Amble, ordnance engineer, A.C.F.; and Major Larue.)

aspects of the defense effort, traffic and maintenance. The engineer's invaluable contribution in this crucial period hinges upon his help not only in the key occupation of production, but in the equally vital one of traffic. Because the time element is all-important, the moving of materials to their immediate destination looms as the engineer's necessary activity. Another phase equally important that has not received adequate attention is that of maintenance. "Cannibalizing," the breaking down of an assembled unit to get parts, has been frequent. It should not be. The engineer's job is to provide against this wasteful procedure, wasteful in time and in material. Col. Walsh then proceeded to comment upon the mechanical engineers' excellent reputation for co-operation with the government and said that he trusted as usual they would rally to solve these problems of production, traffic, and maintenance, bearing in mind the fact that time was the deciding and most precious element.

President Parker Addresses Cleveland Engineers

The subject, "Professionalism in a Profession," was the topic of President James W. Parkers' address before 50 members of the Cleveland Section at their Jan. 8 meeting. In his talk the speaker drew distinctions between professionalism and unionism, ending with a plea for engineers to become more interested in labor relations because of the eminent part they are playing now in our war effort and will play in the peacetime reconstruction.

Wright Field Research Outlined at Colorado

The Jan. 23 meeting of the Colorado Section was a joint one with the Student Branch of the University of Colorado. Lloyd Gardner, a member of the Branch, read a paper "Testing Aircraft Propellers," which had been prepared for the *Engineers' Bulletin*, a publication of the Colorado Society of Engineers. The paper covered Mr. Gardner's summer experience while employed by the Hamilton Standard Propeller Co., stressing design and testing methods relative to modern aircraft propellers.

Major Reeves, of Lowry Field, Denver, Colorado, spoke on the topic, "Research at Wright Field." In his talk, Major Reeves explained the normal functioning of the Air Corps, which constitutes design, testing, and construction. Major Reeves said that Wright Field, to him, represented the nerve center of the Air Corps and because of this importance, all procedures have been accelerated. Two topics, superchargers and altitude testing, provoked much discussion. In summary, the speaker explained various aircraft names, terms, numbers, and symbols. Then followed an hour and a half of discussion.

Story of Plastics Heard at Columbus Section

Members and guests at the Jan. 19 meeting of the Columbus Section heard H. C. Gahl, Development Supervisor, Micarta division, Westinghouse Electric and Manufacturing Co., Trafford, Penn., speak on plastics. In his discourse he briefly described various types of plastics and their manufacture, discussed their properties, and outlined uses to which they are applied.

Innovation in Forum Meeting on Unionism at Detroit Section

For the first time in many years, a forum meeting replaced the usual lecture at the Jan. 20 gathering of the Detroit Section. The closed meeting of over 45 members discussed the urgent issue, "Unionism of Technical Personnel." Blair K. Schwartz, personnel-relations director of The Detroit Edison Co., led the discussion. He outlined rules of the forum, and made clear the fact that probably no definite conclusion would be reached, but that many points of view would be presented. Main commentators were Harold W. Holmes, president of Labor Relations, Inc., and Dean C. J. Freund of the University of Detroit, chairman of the Committee on the Economic Status of the Engineer. During the two-hour period many members expressed valuable sentiments concerning the topic and a desire for a repetition of the same type of meeting again.

One hundred fifty members convened for the Feb. 3 meeting at the new Horace H. Rackham Memorial Building to hear Dr. J. D. Tebo, of the Bell Telephone Laboratories, describe design problems and developments of the cross-bar switching system for dial telephones. Slides and moving pictures illustrated the discussion. Harvey G. Melhouse, of the Western Electric Co., Chicago, described manufacturing problems and explained how the production department performed to meet the exacting requirements of the laboratories. Slides, working models, and displays made the talks more graphic.

East Tennessee Inspects Watts Bar Project of TVA

More than 75 members and guests of the East Tennessee Section, on Jan. 31, visited the Watts Bar Project of TVA. During a trip that lasted six hours, members viewed the hydro power plant, dam, and steam power plant, all of which proved stimulating.

President Parker Addresses Joint Section and Student Meeting, Florida Section

Fifty members and guests at the Jan. 12 meeting of the Florida Section heard President James W. Parker's interesting talk on "Problems Involved in Converting Peacetime Activities to a War Basis." In the body of his talk, President Parker predicted that numerous changes would result in the organizational setup of war industries (some of which have already occurred since his visit). Following the talk, opportunity was given to the executive-committee members and others to say a few words. The entire program was thoroughly enjoyed by all.

Machinability of Steel, Topic at Fort Wayne Meeting

William Splinter, at the Jan. 8 meeting of the Fort Wayne Section, gave a short history of cold-drawn steel and then discussed machinability of different types. Much to the interest of his audience, he then proceeded to explain the action of a tool in cutting metal, the reason for tool wear, chip formation, etc. His talk was illustrated by samples of odd cold-drawn shapes.

Hundred-Horsepower Hands at Greenville Meeting

On Jan. 21, members and guests of the Greenville Section heard Maxwell C. Maxwell discuss material handling, or as he called it, hundred-horsepower hands. His interesting lecture was made more graphic by the presentation of a motion picture on the subject.

Talk on Subversive Activities at Hartford Meeting

A special agent of the Federal Bureau of Investigation, James T. Madigan, was guest speaker at the Jan. 12 meeting of the Hartford Section. He outlined work of the FBI in combating subversive activities, restricting enemy aliens, and planning for plant protection. The speaker suggested, in order to further the excellent work being done in plant protection, that all suggestions on protection, or reports of suspicious actions or incidents, be reported to him at his New Haven office.

Kansas Hears About Steam-Generating Units

"The Design of High-Pressure and High-Temperature Steam-Generating Units" was the subject on Jan. 26 at the monthly meeting of the Kansas Section. John Van Brunt, vice-president in charge of engineering of the Combustion Engineering Co., presented an interesting illustrated lecture. He described in general some of the problems encountered in design and construction of steam-generating units. He then related the theory and problems involved in water and steam circulation and spoke briefly on forced-circulation boilers. Discussion followed.

Los Angeles Section Holds Joint Meeting With A.I.E.E.

Members and guests of the Los Angeles Section at their Jan. 13 meeting heard C. P. Gorman and W. C. Rowse, both of the Los Angeles Bureau of Power and Light, discuss "Principal Features of the New Harbor Steam Plant." The two speakers were especially qualified to discuss this topic, being at present in the midst of design work on the plant. The Bureau of Light and Power is building a steam

plant to augment generating facilities of its electrical system. The installation will comprise two 65,000-kw units with the design calling for an ultimate capacity of 350,000 kw.

Milwaukee Section Meeting Held in 20 Below Zero

Despite zero weather, the hardy souls of the Milwaukee Section held their monthly meeting on Jan. 7. The speaker of the evening, R. H. Bennewitz, of Linde Air Products, chose as his topic, "Flame Cutting and Hardening." His lecture was vivified by a demonstration of oxyacetylene welding in laboratory work. The cutting and grooving features of his demonstration were exceptionally absorbing.

Panel Discussion Held Jointly by New Haven Section and S.A.M.

More than 60 members and guests at the joint meeting on Jan. 30 of the New Haven Section and the Connecticut Chapter of S.A.M. held a panel discussion on "Youth, the Schools, and Industry." Dr. Alonzo G. Grace, commissioner of the Connecticut School of Education, was chairman. The panel consisted of six men, representing education, industry, and one trainee in industry. Special stress was placed upon defense industries, emphasizing the long-term trend of industrial education not only in our present emergency but in rehabilitation for peacetime. This topic proved especially thought-provoking and timely.

Norwich Engineers Learn of Heat-Treatment of Steel

To an absorbed gathering of more than 75 members and guests at the Jan. 20 meeting of the Norwich Section, Dr. R. F. Miller detailed the background of heat-treatment by means of the eutectoid and "s" diagrams and numerous slides showing resultant microstructures of the metal. Following Dr. Miller's talk, a sound film, "Steel—Man's Servant," was shown and proved of unusual interest.

Lubricating Oils the Theme at Ontario Meeting

The Ontario Section meeting of Jan. 8 was attended by 60 members. The speaker of the evening was F. L. Koethen, of American Lubricating Oils, Inc., of Buffalo. The paper "Some Observations on Lubricating Oils," written by Dr. A. W. Burwell of Alox Corp., Niagara Falls, was explained by the speaker. Test figures from a lubrometer were shown in graph form to illustrate the effect of additives. Dr. Burwell's son, R. B. Burwell, also spoke, telling of certain test results obtained in their laboratory.

High-Speed Photography Featured Before Record Philadelphia Crowd

On Jan. 27 the monthly meeting of the Philadelphia Section, attended by more than 300, was high-lighted by a talk and demonstration presented by Prof. Harold Edgerton of the department of electrical engineering of M.I.T. The speaker explained numerous pieces of equipment which he had developed for taking instantaneous pictures of bullets in motion and similar high-speed objects. Many slides of such pictures were shown to the audience.

Providence Engineers Hear About Rotating Machines

The regular monthly meeting of the Providence Section, attended by 75 members and guests, had as its speaker of the evening, Dr. Robert Fehr, of the General Electric Co. He presented the general theory of dynamic balancing and the various types of machines used for balancing. He also described in detail the portable balancer. Photographs showing specific problems of local manufacturers were shown, the problems described, and means of balancing parts presented.

600 Attend Meeting of A.S.M.E., A.I.E.E., and Indiana Power Engineers at St. Joseph Valley

On Jan. 27, 600 members and guests of A.I.E.E. and Indiana Power Engineers met jointly with A.S.M.E. members of St. Joseph Valley Section. The speaker of the evening, Wm. Courtenay, chose as his topic "The Battle of Britain," and presented the urgent and timely problem of the Allies' need for air mastery in order to win the war.

A.S.M.E. Analyzed at Texas Meeting

The Jan. 16 meeting of the Texas Section concerned itself with a summary of A.S.M.E. activities for national defense, methods of improving meetings, and obtaining nationally known speakers. The session closed with a reminder of the coming A.S.M.E. meeting at Houston.

Waterbury Discusses National Defense in the Air

Since air defense is of prime importance in the present war, members of the Waterbury Section at their Jan. 20 meeting were much interested in the timely address of Robert F. Lybeck, entitled, "National Defense in the Air." The speaker said the growth of the aircraft industry has been phenomenal, its dollar output for 1941 exceeding even that of the automobile industry's peak year, 1939. The petroleum industry, following suit, has likewise grown amazingly, increasing its output by $12^1/_2$ times since 1941. Then the speaker made a statement that lifted the cloud of doubt from many minds. He said that a current comparison of domestic and foreign planes reveals that U. S. aircraft are superior in speed, range, fire power, and maneuverability.

Utah's Resources Revealed at Local Section Meeting

Members of the Utah Section on Jan. 27 heard about their state's vast natural resources. Ora Bundy, guest-speaker, whose topic was, "Industrial and Mineral Resources of Utah," outlined problems confronting the Industrial Commission, such as to determine resources, e.g., magnesium, alumite, vanadium, and sulphate deposits, to stabilize farm producers due to the industrialization, and lastly to conserve water resources.

Problems That Challenge at Washington Section

One hundred members and guests at the Jan. 8 meeting of the Washington, D. C., Section heard Dr. Lillian Gilbreth speak on "Problems that Challenge Us Today." One of the major contemporary problems presented by the speaker was the need for integrated organization in family life. Then followed a general discussion of management problems, emphasizing the need for planning and hard work.

Industrial Heating Starred at Western Massachusetts

Climaxing a gala day featuring a trip through the H. B. Smith Co. plant, a cocktail party, and dinner at the Park Square Hotel, the Western Massachusetts Section held its regular evening meeting on Jan. 20, with more than 60 members and guests attending. Prof. Lauren E. Seeley, of Sheffield School, Yale University, chose as his topic, "Modern Industrial Heating." He commenced his discourse with remarks on heat control, observing that the time between three and four o'clock, when human vitality is at its lowest, therefore requiring higher temperatures, had direct bearing on employment, especially recently with the high universal advent of the third shift in industry. Air motion, relative humidity, generation, absorption, and dissipation of heat were further topics. The speaker then stated that the problem of cooling in summer was being emphasized by labor unions to be of equal import with that of heating. Such detailed information as he gave proved invaluable.

Products of Powder Metallurgy Popular at Worcester

One hundred members and guests at the Jan. 13 meeting of the Worcester Section kept George E. Platz answering questions till midnight. The speaker, who is chief engineer, Amplex Division, Chrysler Corp, Detroit, spoke on "Products of Powder Metallurgy." Some products of this infant industry are oil-oozing bearings, gears, and bullets, called by the speaker oilite, superoilite, etc. A number of samples were displayed.

With the Student Branches

Arkansas Holds Smoker-Meeting

A SMOKER-MEETING was held by ARKANSAS BRANCH on Jan. 21. Following technical talks by two members, Prof. L. C. Price, who is leaving the University to go to Michigan State College, was presented with a desk set. The evening was concluded with the serving of refreshments and a demonstration by a professional magician.

BUCKNELL BRANCH held a meeting on Nov. 26 at which Harry McCulley showed motion pictures. One picture, "Locomotive Repair," illustrated the complete process of tearing down, cleaning, and rebuilding of a locomotive. The other films consisted of "An Evening With Edgar Guest," and "The Home Beautiful."

Caltech Visits Movie Studio

An invitation was extended to 15 members of CALIFORNIA TECH BRANCH by the engineering department of Paramount Pictures, Inc., to visit the company's studios on Oct. 31. Objects of technical interest were sound recorders, cameras, transparency background projectors, tank and wave machine for sea pictures, heating and ventilating plant, and various shops. The behind-the-scenes appearance of the scenery made of paper, plaster of paris, and sheet metal, caused much comment among the visitors.

CINCINNATI BRANCH had an audience of 85 members and guests at its Jan. 20 meeting. Robert Schlueter, chairman of the intramural committee, reported that A.S.M.E. teams had reached the finals of the volleyball contest and the handball quarter-finals, and had won the only basketball game played so far. He also stated that competition in bowling and boxing would soon start. The meeting was concluded with the showing of a motion picture on the production of airplane engines.

C.C.N.Y. BRANCH opened its spring semester with a meeting on Feb. 5 at which 65 members and guests heard Robert Kay, chairman of the Branch, discuss the functions of the organization and its many advantages. It was announced that an honorary mechanical-engineering fraternity, Alpha Mu Epsilon, had been formed at the school through the cooperation of Prof. Clarence H. Kent. The main objective of the new group is to serve as an incentive to lowerclassmen.

COLORADO BRANCH had an inspection trip scheduled on Dec. 15 to the Fort Collins Power Plant, but this had to be canceled because of governmental regulations forbidding the admittance of visitors to power plants. At the Dec. 1 session, Marsh Allen, who had been in the employ of the Hunt Inspection Co., presented a very interesting paper outlining the inspection carried out by his company in the Pueblo Steel Mills.

CORNELL BRANCH held a joint meeting with the Cornell Railroad Club on Jan. 6. The program consisted of a motion picture entitled, "Railroadin'."

DELAWARE BRANCH conducted a session on Jan. 8 during which the following motion pictures were shown: "Ford Rouge Plant," "U. S. Navy Service School," "Ford Reconnaissance Car," and "The Manufacture of Safety Glass."

DREXEL BRANCH devoted its meeting on the evening of Jan. 22 to a paper by J. S. Newton, marine engineer, Westinghouse Elec. & Mfg. Co., on the subject of marine turbines and machinery. Slides were used to illustrate the talk. After the serving of refreshments, the meeting adjourned.

Student Papers at Florida

Student papers presented at the Jan. 16 meeting of FLORIDA BRANCH included "Ground Testing of Power Plants," by J. A. Coll, "High-Octane Gasoline and Safety Fuels," by C. W. Coffee, "Cabin Superchargers," by D. A. Thompson, and "Synthetic Materials as Bearings for Rolling Mills," by C. M. Mullis.

ILLINOIS TECH BRANCH members numbering more than 200 turned out for the special meeting on Jan. 6 in order to welcome to the school the president of the A.S.M.E., James W. Parker. He gave a very interesting talk on the role of the engineer in the world of today. At the Jan. 16 meeting, John Peterson, director of training for the Commonwealth Edison Company, gave a lecture on "Job Instruction Training."

1941-1942 A.S.M.E. STUDENT BRANCH AT CASE SCHOOL OF APPLIED MECHANICS

IOWA STATE BRANCH featured a two-part program at its Jan. 15 meeting. The first part consisted of a motion picture on the methods and processes used to derive copper and nickel from their ore. The second part was a talk by Carl Gesser, instructor in metal casting, who outlined the various foundry processes and showed the relationships between the different departments, such as the pattern making and molding.

Agricultural Engineering at Kentucky

Prof. J. B. Kelley, of the agricultural department, spoke before 74 members and guests of KENTUCKY BRANCH at the Jan. 9 session on "The Agricultural Engineer's Work." According to the speaker, agricultural engineering started as a profession in 1907 in Madison, Wis., with the formation of the American Society of Agricultural Engineers. The society now embraces more than 900 members. Courses in the subject are being offered by 28 institutions in the United States. There are six courses in agricultural engineering at the University, namely, mechanics of farms, rural electrification, structural engineering in farming, engineering practices and farm management, farm motors, and shop courses in metals.

MISSISSIPPI STATE BRANCH'S secretary-treasurer, S. V. Craft, gave a very informative talk on "The Priorities System" at the Jan. 8 meeting. He set forth the theory upon which the system is based; the necessity of such a system to the vast defense program; and the proceedings and methods utilized by the O.P.M.

MISSOURI BRANCH announced the holding of a special dinner on Feb. 20 in honor of the fiftieth anniversary of the inauguration of a mechanical-engineering curriculum at the University of Missouri. According to Prof. E. S. Gray, honorary chairman, the speakers included President F. A. Middlebush, Prof. Emeritus A. J. Westcott, Col. A. McIntyre, Prof. Emeritus W. S. Williams, and Dean H. A. Curtis.

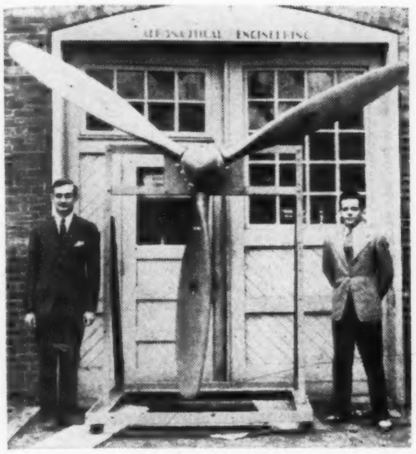
MISSOURI MINES BRANCH reports a scarcity of outside speakers because all engineers are kept busy day and night on national-defense work. Consequently, the meeting of Jan. 7 was devoted to the showing of two motion pictures, "Dodge Fluid Drive" and "Making of the Ford V-8 Engine."

MONTANA STATE BRANCH featured talks by student members at the Jan. 16 and 23 meetings. Among the speakers were William Jefferies, Robert Johnson, Don Jacobson, and William Gibbs.

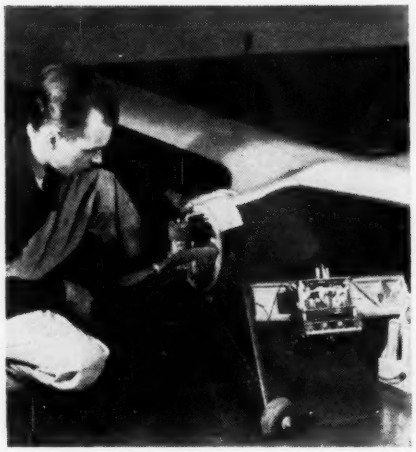
NEBRASKA BRANCH held an election of officers for the coming semester at the Jan. 14 session. The technical part of the meeting consisted of a motion picture and talks by William Haskins and John Lister, Socony-Vacuum Co., on bearing lubrication.

Walter Kidde Award at Newark

At the Jan. 16 meeting of NEWARK BRANCH, Professor Ritterbusch, honorary chairman, called the attention of the 100 members present



GEO. TOPINKA (LEFT) AND WARREN JAMES WITH PROPELLER USED IN DEMONSTRATION AT DEC. 2 MEETING OF PURDUE



KENNETH HARKER WITH DEMONSTRATION EQUIPMENT USED FOR TALK GIVEN AT DEC. 16 MEETING OF PURDUE BRANCH

to the contest which is open to them and the opportunity of winning the Walter Kidde Award and $50 in cash. This year's contest is based on "The Life of John De Hart," and will close on June 1, 1942. The judges will look for the following qualities in each essay submitted: Composition, dramatization, the work of Mr. De Hart in fields other than technical, effectiveness and appreciation of the engineer's responsibilities in civic life. The guest speaker of the evening was Ivan Harkleroad, superintendent of experimental test of the Wright Aeronautical Corporation, who spoke on "The Development of the Wright Engine."

N.Y.U. BRANCH (aeronautical division) was addressed on Jan. 14 by Gerald Fogel, student member, on the subject of "The Tricycle Landing Gear." According to the speaker, the advantages of this gear are that (1) the airplane in landing is not bounced back into the air, (2) there is no danger of nosing over, and (3) since the airplane is parallel with the ground, the pilot has much better visibility at take-offs.

NORTHEASTERN BRANCH called a meeting on Dec. 11 to discuss a letter received from Prof. Charles F. Scott, representing the E.C.P.D. The 60 members present entered into the discussion wholeheartedly. An outcome of the meeting was the selection of a committee to bring about a joint organization of all professional groups on the campus.

Religion in Engineering

The meeting of Jan. 23 of OHIO STATE BRANCH was devoted to a paper on "Religion in Engineering," presented by Prof. Carl A. Norman, assisted by Prof. S. M. Marco. The audience consisted of 87 members and 2 visitors.

OREGON STATE BRANCH had a timely topic, "Unionization of Engineers," at its Jan. 22 meeting. A. D. Hughes, honorary chairman, explained the policy of the parent society on this question. He was followed by Prof. C. A. Mockmore, who claimed that the unionization of engineers was being accomplished by outsiders, not the engineers themselves.

PENNSYLVANIA BRANCH was told by Prof. T. F. Hatch on Dec. 15 that industrial hygiene is of particular importance in wartime, especially in those industries in which respiratory diseases are prevalent. He stated that it was an engineering and not a medical problem that needs solving by engineers.

PITTSBURGH BRANCH members were happy to learn at the Jan. 22 meeting from John Knoll, chairman of the sports committee, that the A.S.M.E. had won the cup which is awarded annually to the campus organization placing highest in the fall intramural program of sports. In addition to this cup, intramural sports medals were presented to individual members of the winning "touch" football and baseball teams. At the meeting on Jan. 29, Robert Erhard read a paper on "A Comparison of Steam and Diesel Locomotive Performance and Economy."

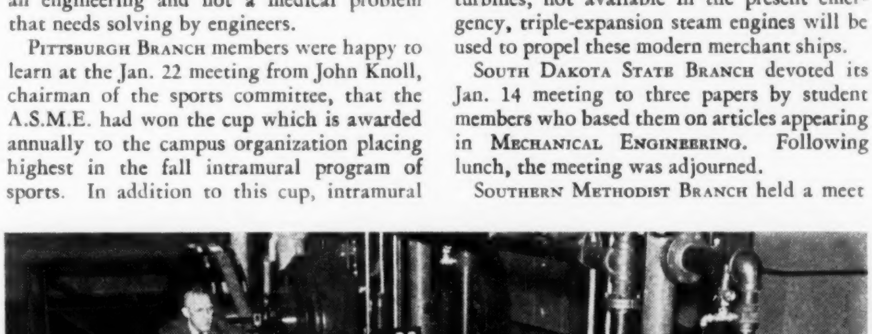
R.P.I. Meets With A.I.E.E.

In order to present a more polished and elaborate meeting, the R.P.I. BRANCH collaborated with the local chapter of the A.I.E.E. in presenting two speakers, L. R. Yeager and J. S. Irvine of the Owens-Corning Fiberglas Corp. The speakers discussed the development of Fiberglas and its diversified uses. Refreshments consisting of cider and doughnuts were served after the meeting.

RICE BRANCH conducted an inspection trip for 48 members on Jan. 7 to the Houston Shipbuilding Corp. The construction of a ship from its beginning in the mold loft as huge basswood patterns, through the shops where finished parts were cut, bent, etc., from sheet steel, and thence to the yards for short-time storage or immediate addition to the ship by powerful gantries, was witnessed. It was noted by the visitors that instead of steam turbines, not available in the present emergency, triple-expansion steam engines will be used to propel these modern merchant ships.

SOUTH DAKOTA STATE BRANCH devoted its Jan. 14 meeting to three papers by student members who based them on articles appearing in MECHANICAL ENGINEERING. Following lunch, the meeting was adjourned.

SOUTHERN METHODIST BRANCH held a meet



IN THE FOREGROUND IS ONE OF THE MOST UNUSUAL MECHANICAL-ENGINEERING FEATURES IN THE NEW HEAT-POWER LABORATORY AT THE UNIVERSITY OF NOTRE DAME

(Shown in operation are two steam-driven air compressors of the mechanical-engineering department hooked up in an amazing fashion that permits almost limitless experimentation. Students and Prof. Carl C. Wilcox, head of the department, at the left, are checking operating conditions. These $12,000 compressors are so arranged that they may be operated either condensing or noncondensing and simple or compound as desired. Furthermore the air piping is so arranged that they may be operated either single or two-stage, while the two steam cylinders are so installed that one may be used as a high-pressure cylinder and the other as a low-pressure cylinder of a compound engine. Professor Wilcox estimates a mechanical-engineering student might spend his entire college career studying with profit the intricacies of these two machines.)

ing on Jan. 13 at which J. Lacy, instructor in the mechanical-engineering department, discussed "The Modern Trends in Diesel Engines." After a period of discussion and questions, the members and visitors adjourned to the mechanical-engineering laboratory where coffee and doughnuts were served.

Ernest Hartford at Texas

Ernest Hartford, executive assistant secretary of the A.S.M.E., and, as many Student Branches have stated frequently, godfather of student members in the Society, was the guest of honor at the Jan. 13 meeting of the TEXAS BRANCH. Prof. V. L. Doughtie introduced him to the assemblage. Mr. Hartford gave a very interesting discussion on the history of the A.S.M E., the many services the Society makes available to Student Branches, and several ways that a Student Branch can make meetings interesting.

TEXAS TECH BRANCH had only a 20-minute meeting on Jan. 5 at which various items of miscellaneous business were transacted.

TUFTS BRANCH did not hold any January meeting because of the greatly accelerated program of courses. At the Feb. 2 session, 59 members and guests were present to view the motion picture entitled, "Wright Builds for Air Supremacy."

VERMONT BRANCH was sponsor of a joint banquet for all engineering organizations on Dec. 17, the first of its kind ever held at the University. Dinner was followed by a party around the Christmas tree with presents for everyone. As a climax to the party, the professors were pervailed upon to lead the group in a song for engineers of their own composition.

VILLANOVA BRANCH is going ahead with plans for the regional conference in the spring at which it will be host to other Student Branches. At the Jan. 12 session, the members discussed a letter received from RUTGERS BRANCH in which a one-day conference, instead of the two-day one usually held, was advocated. The members were favorably inclined toward the idea, but no definite action was taken pending answer from the other Student Branches.

Washington State Strives for $10

It was reported by Arthur E. Tanasse, secretary of the WASHINGTON STATE BRANCH, that at the Dec. 18 meeting Professor Langdon offered to donate $10 in cash to the organization if its membership reached 70 by the end of the fall semester. At the same session, Art Townsend suggested that student members in his and other Branches should take time out to write letters to former members who were serving in the armed forces of their country.

WORCESTER BRANCH welcomed back C. T. Hawley, class of '98, who gave a talk on "Patents in Relation to Engineering" at the Jan. 14 meeting. He explained the nature of patents, the procedure in obtaining them, the engineer's relations in the patent field, and how patent law was an engineering proposition.

YALE BRANCH continues its policy of having student papers presented at each meeting. During January, the following men presented papers: Bonsal on magnesium; Weld on vitamins; Warwick on "Some Observations on the Engineering Attitude;" Warner on "Aquablitzing;" Van Voast on "What the Railroads Are Doing for the War Effort;" Young on "Traffic on Country Roads;" Twigg-Smith on Hawaiian Volcanoes; Parella on "Misconceptions in Illumination;" Tuttle on "Military Trucks;" Wallace on "Battleships or Airplanes?" Turner on "Aluminum;" and Thompson on "Air-Line Safety."

A.S.M.E. STUDENT GROUP AT TEXAS UNIVERSITY TAKEN AT THE TIME OF THE VISIT OF ERNEST HARTFORD, ASSISTANT SECRETARY, A.S.M.E., ON JANUARY 13 OF THIS YEAR

Stout Receives Sperry Award

THE Lawrence Sperry Award for a notable contribution made by a young man to the aeronautical sciences was presented to Ernest G. Stout of Consolidated Aircraft Corporation, San Diego, California, by the Institute of the Aeronautical Sciences on the occasion of its Tenth Anniversary Honors Night Dinner which was at the Waldorf-Astoria in New York, N. Y., on January 27.

Mr. Stout, who is 28 years old, is a graduate of New York University and is now engineer in charge of Aerodynamics and Flight Testing at the Consolidated Corporation. He receives the Sperry Award for 1941, including an honorarium of $250 with the citation "for his contributions to the experimental determination of the hydrodynamic stability of model flying boats and seaplanes." His research on small test models has been a considerable aid to engineers in designing today's large naval and commercial flying boats so that their performance at landing and take-off from the water is accurately known before the completed aircraft is test-flown.

(*A.S.M.E. News continued on page 252*)

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS 1942 STUDENT MEETINGS

	Group	*Host*	*Place*	*Dates*	*Representative of Committee on Relations With Colleges*
I	New England	University of Vermont	Burlington, Vt.	April 24–25	A. C. Chick
II	Eastern	Villanova College	Villanova, Pa.	April 20	A. C. Chick J. L. Hall
III	Alleghenies	Pennsylvania State College	State College, Pa.	April 10–11	R. H. Porter
IV	Southern	University of Tennessee	Knoxville, Tenn.	March 30–31	R. P. Reece
V	Midwest	University of Notre Dame	Notre Dame, Ind.	April 20–21	J. I. Yellott
VI	North Central	Washington University	St. Louis, Mo.	April 17–18	J. I. Yellott
VII	Southwest	University of Oklahoma	Houston, Texas (*In conjunction with A.S.M.E. Spring Meeting*)	March 23–24	H. E. Degler
VIII	Pacific Northwest	University of British Columbia	Vancouver, B. C., Can.	April 27–29	B. T. McMinn
IX	Rocky Mountain	University of Wyoming	Laramie, Wyoming	April 9–10	J. W. Haney
X	Pacific Southwest	University of California	Berkeley, Calif.	March 27–28	G. L. Sullivan

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
29 W. 39th St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

ENGINEER, versatile and with initiative, desires responsible position with progressive manufacturer. Trained metallurgist (Ph.D.), naturalized U. S. citizen, 38, married. Has had 9 years with leading metal producer in research, development, production, and sales. Three years manager of foreign-trade corporation; import, export, marketing, advertising, technical writing, and promotion. Now industrial consultant and technical adviser to machinery manufacturer. Me-733.

ADMINISTRATIVE ENGINEER, Cornell graduate, 31, married. Experienced plant engineering, layout, production synthetic resins, plastics. Now employed. Desires position same field with progressive concern. Will go anywhere. Me-734.

CONSULTING ENGINEER, M.E., 35 years' experience; in professional practice since 1938. Experienced in design of boilerhouses, machine shops, power plants, steam distribution, heating, ventilating, air-conditioning, and plumbing systems. Me-735.

GRADUATE MECHANICAL ENGINEER, 45, with diversified experience and managerial aptitude; development and production of heavy equipment of precision character, various phases of industrial and plant engineering. Prefer permanent Midwestern location. Me-736.

MECHANICAL ENGINEER, 33, single, B.S. and M.S. degrees. Extensive experience as college instructor, development and research engineer, production and design. Registered engineer. Executive-type position desired. Me-737.

MECHANICAL ENGINEER, experience of 25 years in design, construction, operation, and management of all classes of power plants and public utilities. Both mechanical and electrical training. Me-738.

MECHANICAL ENGINEER, graduate electrical engineer, 15 years' experience in design, development, testing, and installation of fluid measuring and control equipment. Five years' supervisory experience in design. Also 3 years' plant engineering experience in general upkeep and new machine installations in heavy-industry plant. Now employed. Desires connection in aircraft or processing industry. Me-739.

GENERAL AND SALES MANAGER, 43, married, college graduate, M.E. degree, and P.E. license, excellent background, capable organizer and manager; tactful, resourceful, broad experience in engineering, sales and general management; with present company 17 years. Me-740.

[1] All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

MECHANICAL ENGINEER, 30–45, for design, drafting work, and when ability has been demonstrated, supervision over others. Should have good experience in machine-shop methods. Steel-plate fabrication, structural steel, or chemical-plant design experience helpful. Western New York. Y-9227.

DESIGNER, MECHANICAL for line of production machinery of medium weight, semiautomatic type. Must be A-1 man capable of creating ideas of new design. Must be U. S. citizen. Salary, $4200. Permanent. New Jersey. Y-9754.

GRADUATE MECHANICAL ENGINEER, possibly June, 1942, graduate, for laboratory work. Since no design work or other work outside of laboratory is demanded, no experience is necessary, but schooling should have emphasized laboratory work. Must be deferred from draft. Will make extensive investigation of various forms of agitation as well as development of new styles of agitators. Will build simple laboratory apparatus, as well as set up life tests for existing equipment. New York State. Y-9763.

EMPLOYMENT MANAGER, 35–50, with previous experience with manufacturing company. Must be thoroughly acquainted with job classification and analysis; some rate-setting and industrial-relations work. Plant employs 2500 men. Salary, $4000–$5000 a year. South. Y-9779.

MECHANICAL ENGINEER experienced in layout of heavy machine tools; must have knowledge of machine-shop operation and be capable of taking complete charge of laying out on paper large shop now being built. Salary, $3600 a year. Upstate New York. Y-9784.

GRADUATE MECHANICAL ENGINEER, 24–45, with good background in mechanical design of high-precision parts. Work will not involve board work although development of ideas and mechanical changes will be involved. Permanent. Salary open. New Jersey. Y-9792.

PRODUCTION MANAGER experienced in modern methods of mass production and with knowledge of explosives for shell-loading plant. Salary, $6000 year. Location, East. Y-9798.

PRODUCTION CONTROL MANAGER, mechanical or industrial engineer, thoroughly familiar with visual production control, load chartings, methods, etc. Salary, $3600–$4800. New York State. Y-9836.

INDUSTRIAL ENGINEER, 30–45, preferably graduate industrial or mechanical, to be assistant to chief engineer, particularly in field of operating standards. This includes from operation analysis and time study development and specification of: machine-tool speeds, feeds and depth of cut; operation description; proper jigs, fixtures, and cutting tools; standard time per unit of production for all productive divisions, which include foundry, tank shop with welding, machine shop with a full range of medium and heavy machine tools, assembly, and testing. Salary open. Pennsylvania. Y-9843-D.

TOOL ENGINEER capable of layout of jigs for cost reduction in plant manufacturing machine tools. Complete knowledge of shon routing and experience in tool design essential. Opportunity to become head of methods and tool department. Salary, $3900. New England. Y-9844.

INDUSTRIAL RELATIONS MANAGER, 32–40, for machine-tool company employing 500 employees. Must have experience in interviewing, job analysis and classification, union negotiations, workmen's compensation, etc. Salary, $7500. New England. Y-9845.

CHIEF INSPECTOR for machine-tool plant manufacturing high-precision small parts. Experience in this essential. Must be aggressive though tactful in handling of inspection problems. Will carry complete responsibility in this work. New Jersey. Y-9847.

EXECUTIVE, 35–40, with several years of responsible operating experience in electrochemical or metallurgical industry. Technical education essential. Should have appreciation of labor relations and cost systems. Must have pleasant personality. Salary open. West. Y-9865-CDS.

PROCESS ENGINEER for metal-products manufacturing plant, 28–40, preferably married. Man should have good knowledge of capability and limitations of standard machine tools, and be able to correctly prescribe operations which should be performed in manufacturing each part of the product. Should have jig-and-fixture experience. Must be U. S. citizen. East. Permanent. Salary open. Y-9875-(a).

MANUFACTURING EXECUTIVE, 40–50, graduate mechanical engineer, thoroughly versed in machine-tool operations; qualified by experience to assume executive responsibility for operation of moderate-sized, well-integrated metal-products manufacturing plant. Ability

(A.S.M.E. News continued on page 254)

C-E RAYMOND BOWL MILL

Setting . . . . . TODAY'S STANDARDS OF COAL PULVERIZER PERFORMANCE

New concepts of efficient and economical pulverizer performance have been established by hundreds of installations of C-E Raymond Bowl Mills in public utility and industrial plants. The mill illustrated here is one of the larger sizes. C-E builds a complete range of sizes for all capacities.

A 635

COMBUSTION ENGINEERING

200 Madison Avenue — C-E — New York, New York

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

to operate along organization lines and to train subordinate department heads and labor foremen essential. Must be U. S. citizen, U. S. ancestry. Apply by letter, stating education, experience, and salary desired; enclose snapshot. New England. Y-9875-(b).

TECHNICAL DIRECTOR, preferably married, 35-45, graduate mechanical engineer, for medium-sized mechanical-products manufacturing company, to direct and co-ordinate the activities of its technical division. Must be creative and aggressive. Position will appeal to design or technical engineer who has acquired some knowledge of manufacturing operations. Must have marked administrative ability. Apply by letter, giving full details as to education, experience; enclose snapshot. Must be U. S. citizen. New England. Y-9875-(c).

MAINTENANCE ENGINEER, 30-40, preferably with mechanical-engineering background. Should have well-rounded experience in manufacturing-plant maintenance and power-plant operation. Must be U. S. citizen. Permanent. East. Y-9875-(d).

MECHANICAL OR ELECTRICAL ENGINEER, 25-40, with manufacturing or research experience in durable goods, i.e., manufactured articles of metal, glass, electrical appliances, to do research in alternative materials and technique, cost analysis, time studies, etc. Salary, $3200-$4600 a year. Washington, D. C. Y-9906.

MECHANICAL ENGINEER, young, capable of assuming responsibilities and looking for opportunity to increase his effectiveness. Should have 5 to 12 years' experience in power- and industrial-plant design, heat-balance computations, specifications, and project engineering. Past experience with large engineering company or equivalent desirable. Starting salary, about $4800. Permanent. Pennsylvania. Y-9911.

GRADUATE MECHNICAL ENGINEER with minimum of 10 years' experience. Should be capable of handling engineering department for firm of architects doing defense work—housing, schools, public, private, and institutional buildings. Must have executive ability and be designing engineer and specification writer. Duration, one year. Write letter stating salary desired. South. Salary open. Y-9924.

MECHANICAL ENGINEER who has good knowledge of machine-shop operations to act as project engineer in following through jobs to completion. Must be able to estimate time and costs and speed production. Salary open. Location, New Jersey. Y-9941.

MECHANICAL ENGINEER, 28-35, with some production experience, preferably along chemical-plant lines, to become production executive in plant manufacturing asphalt products. Salary, $3000 year. Maryland. Y-9942.

MECHANICAL OR ELECTRICAL ENGINEER, 35-50, with several years' experience in design of small mechanical mechanisms. Several years' actual experience on design board preferred; man must be capable of general supervision of mechanical development work. Salary open. New York, N. Y. Y-9950.

POWER-PLANT DESIGNING ENGINEER capable of designing both electrical and mechanical phases of large industrial power plant. Duration one year. Salary $4800 year. Middle West. Interviews, New York, N. Y. Y-9959.

PERSONNEL MANAGER, 35-43, to handle the employment of personnel for plant of about 3000 employees, male and female. Ability to select capable machine-tool operators and machine hands. Knowledge of labor negotiations in organized shop essential. Salary open. East. Y-9960.

WORKS MANAGER, mechanical engineer much practical experience in machine-shop practice. Will have complete charge of shops; also large, modern welding department, pattern shop, etc. Permanent. $5400-$7200 year. Middle West. Headquarters, New York, N. Y. Y-9967.

PRODUCTION ENGINEERS with some past experience in planning, scheduling, or estimating work in machine-tool plant. Knowledge of nonferrous metals operations helpful. Must be citizen of U. S. Permanent. New Jersey. Y-9974.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after April 25, 1942, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ANDREWS, ALBERT H., Bethlehem, Pa.
ANTHONY, WM. C., Streator, Ill.
BITKO, SOL, Brooklyn, N. Y.
BUSH, RALPH R., Manoa, Pa.
DEARBORN, C. BASIL, JR., Dumont, N. J.
EADDY, ERNEST J., Spartanburg, S. C.
FORSYTHE, ALFRED V., Kansas City, Mo.
FREEMAN, ROBT. G., Flint, Mich.
GOLDSMITH, CLARENCE S., Brooklyn, N. Y.
HARWICK, HARRY K., Philadelphia, Pa.
KACMARCIK, VLADIMIR E., Brecksville, Ohio
HALL, GORDON, Hamilton, Ont., Canada
HAMLEN, EARLE K., Akron, Ohio
HARRINGTON, ROBT. L., Medford, Mass.
HEINTZ, RALPH MORELL, Shaker Heights, Ohio
IRVINE, J. A., Demarest, N. J.
KITT, HOWARD G., Philadelphia, Pa.
KREINER, ANTHONY J., Cleveland, Ohio
KYLE, JOHN J., Philadelphia, Pa.
MILLER, ROBERT O., Lynn, Mass.
MOTT, HAROLD E., Brantford, Ont., Canada
PALM, AXEL E., Metuchen, N. J.
PARDO, VINCENT A., Wayne, Pa.
SALTER, TOM, Wichita, Kan.
SCHREIBER, NORMAN B., Chicago, Ill.
SHAPIRO, ASCHER H., Cambridge, Mass.
STEPHENS, RUSSELL M., Washington, D. C.
STOLP, WM. J., JR., Kingsport, Tenn.
TALAY, JOHN J., Detroit, Mich.
WAN, CONRAD CHANG-YEN, Philadelphia, Pa.
WELLS, E. S., JR., Chicago, Ill.
WELLS, WM. D., Larchmont, N. Y.

CHANGE OF GRADING

Transfer to Fellow

HOGG, JOHN W., Broomall, Pa.

Transfers from Junior

IRELAND, MARK L., JR., Hilton Village, Va.
LINDAHL, ERIC J., Columbus, Ohio
MORRISON, THOMAS, Toronto, Ont., Canada
ROWLEY, LOUIS N., JR., New York, N. Y.
VOKAC, CHAS. W., Chicago, Ill.

A.S.M.E. Transactions for February, 1942

THE February, 1942, issue of the Transactions of the A.S.M.E., contains:

Combustion of Four Fuels in One Boiler, by W. J. Lutz
Piston Effect of Trains in Tunnels, by R. L. Daugherty
Developments in Regulating Outlet Valves, by G. J. Hornsby
The Performance of Flat-Plate Solar-Heat Collectors, by H. C. Hottel and B. B. Woertz
A Method for Determining Unsteady-State Heat Transfer by Means of an Electrical Analogy, by Victor Paschkis and H. D. Baker
Steels and Alloys Developed for Use at Elevated Temperatures in Petroleum Refineries as Still Tubes and Other Parts, by B. B. Morton
Experimental Study, Feedwater Treatment for 1400-Lb Boiler Operating Pressure, by D. C. Carmichael
A Study of Damper Characteristics, by P. S. Dickey and H. L. Coplen
Operating Experiences With High-Pressure High-Temperature Unit at Des Moines, by J. F McLaughlin

Necrology

THE deaths of the following members have recently been reported to headquarters:

ARMITAGE, HENRY B., November 12, 1941
ARNOLD, BION J., January 29, 1942
BOOKER, HOMER N., October 2, 1941
CAUGHEY, REED J., January 4, 1942
FERGUSON, JOHN W., February 4, 1942
HEATH, DELOS P., November 30, 1941
MCINTIRE, CHARLES V., June 10, 1941
SADA, LUIS G., September 5, 1941
WESTIN, CHARLES J., January 29, 1941